May 23, 1952

THE ENGINEER

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Annual Report of the North of Scotland Hydro-Electric Board

THE North of Scotland Hydro-Electric Board has now published its report for the year 1951. During that year the hydro-electric schemes built by the board reached the stage of large-scale production for the first time. By the end of the year over 280MW of new hydro-electric power were available, producing 576 million kWh per annum and the total hydro-electric production, including the output of the pre-war Grampian stations at Rannoch and Tummel had reached the rate of nearly 900 million kWh per annum, which, it is stated, is equivalent in terms of coal to about 570,000 tons per annum, or well over one week's output of all the Scottish coal pits. When the hydro-electric schemes now being surveyed, promoted and constructed are in operation this production will be nearly quadrupled. The total demand of the board's consumers reached a peak of 242MW in December, 1951, 33MW more than the peak of 1950. This increase is equivalent to half the capacity of the newly commissioned Affric scheme; the increased demand took place almost entirely in the agricultural parts of the area. In addition to meeting the requirements of its own area, the board made every effort to send as much power as possible to Central Scotland; in December a peak amount of 198MW was delivered, 13MW in excess of the 185MW which the board had contracted to deliver. Capital expenditure during 1951 amounted to £11,409,786, bringing the total of the board's capital expenditure at December 31st up to £69,128,378. A substantial volume of work is in hand and the total of borrowing consents already given is £92,855,613. The profit for the year after meeting all costs and charges was £16,520. During the year four new hydro-electric schemes—known as Breadalbane, Orrin, Shin and Kilmelfort—were published, and negotiations continued on the Mucomir scheme, which was published in 1950. The output of these five schemes will be about 568 million kWh annually, with an installed capacity of 155MW; three schemes for transmission lines were promoted during the year. The board's programme of research and development included work on building in stone, various agricultural experiments involving the use of electricity, and further progress with the wind power experiments and the peat-fired gas turbine which the board has sponsored.

The Food Canning Industry

THIS week the Anglo-American Council on Productivity has published the report of a team which visited the U.S.A. last year to examine conditions and methods employed in the food canning industry. It is a report which contains much that is interesting to engineers, as many pages are devoted to fairly detailed descriptions of the machinery and processes used in America's extensive food canning activities. The report says that "no team could go from this country to America without being deeply impressed by the demonstration of what can be achieved by the utilisation and adaptation of machines and mechanical aids to replace physical labour." The team noted throughout its tour that everything in the food canning industry of the U.S.A. that can be mechanised is mechanised, with the result that the movement of raw materials and finished goods is reduced to the minimum. Furthermore, the report comments, many simple devices are used to ensure that the flow continues uninterruptedly, there being much improvisation and ingenuity. The members of the team were also impressed by the well-defined and progressive attitude towards machines in the American canning industry. They are not regarded as long-term investment, the report says, but as replaceable equipment to be used at once to the utmost productive capacity, and to be discarded—even if they still work efficiently—immediately anything better is available. In the general recommendations included in the report food machinery manufacturers in this country are urged to study the various classes of machinery available to canners in the U.S.A. and to make every effort to introduce here more modern and more efficient machines capable of running at higher speeds. The maximum benefits from mechanical improvements, the team suggests, can be realised only by the development of closer collaboration between can makers, machinery makers and canning firms.

The Railway Accident at Weedon

THE Ministry of Transport has now issued the report of the inquiry into the accident near Weedon, on the London Midland Region of British Railways, on September 21, 1951. In this accident the 8.20 a.m. up express train from Liverpool to Euston was derailed when travelling at 60–65 m.p.h., and as a result fifteen persons lost their lives and thirty-six were injured more or less seriously and twenty-five received minor injuries. The train was on the leaving transition of a left-handed curve of about 50 chains radius when the leading bogies of the engine were derailed to the right as a result of an engine defect. The derailment was not noticed and the train continued forward at speed for more than three-quarters of a mile. The whole train, except the last two vehicles, then left the track, the engine fell down a 12ft high embankment, and the wreckage of the eight leading coaches was piled up behind and alongside the engine across both tracks. In his conclusions to the report Lieut.Colonel G. R. S. Wilson, the chief inspecting officer of railways, states that there is no doubt that the derailment of the leading wheels of the locomotive bogie, which led to the accident, was brought about by the lack of freedom of the axleboxes in the horns. The bogie wheels of the locomotive had just been changed from back to front and examination after the accident had shown that both of the leading axleboxes were much too tight. As a result of this tightness the freedom of the leading wheels of the locomotive to follow the ordinary inequalities of the track had been severely restricted. It is pointed out that the transposition of bogie axles had been carried out for many years on the L.M.R. without failure, and the report recommends that the standards and methods to be adopted should be fully and precisely laid down, and final responsibility for ensuring the work is carried out correctly should rest with a senior member of the supervising staff.

Incorporated Plant Engineers' Conference

THE fifth annual conference of the Institution of Incorporated Plant Engineers began at Harrogate on Wednesday and ends to-day, Friday. Mr. G. A. Rooley, A.M.I.Mech.E., is the president of the Institution, and yesterday morning he delivered an address to the conference in the course of which he emphasised the many responsibilities of a plant engineer. If, Mr. Rooley said, it was accepted that a professional plant engineer was one engaged in the supervision, maintenance or control of fixed or mobile plant, there could not be any doubt about his scope and his responsibilities. The latter, he suggested, involved making coal do more work, making machines accomplish more per revolution, and making floor area accommodate more machines. From inquiries he had made, Mr. Rooley said it appeared that the cost of maintenance of plant and buildings, together with the cost of fuel, power and other engineering services, ranged between 4½ per cent and 20 per cent of the total production costs. The wealth of a country, Mr. Rooley continued, was in the work that it did, so that, however cheaply raw material could be bought, the wealth of the nation would be largely measured and determined by the cost of getting and processing. If the plant engineer was responsible for something approaching 20 per cent of that cost of processing, it was important that his department and the administration should work together, each realising the scope, ability and usefulness of the other. Mr. Rooley then referred to the productivity and specialist teams which had been despatched to learn what was happening in other countries in order to tell industry in this country how it could improve its methods. He ended his address by claiming that here an "industrial revival" was needed, putting as the essentials: greater production of coal, more financial and technical incentive to economise, and a reduction of restrictive practices on all sides.

The Illuminating Engineering Society

THE summer meeting of the Illuminating Engineering Society is being held at Eastbourne this week. After the inaugural meeting on Tuesday, May 20th, the technical sessions began on Wednesday, May 21st, when Dr. W. S. Stiles presented his paper on "The Eye, Brightness and Illuminating Engineering," which reviewed the basic facts about brightness and its role in vision, discussed the properties of the eye and the desirability of limiting brightness or brightness ratio in the field of view, and investigated the suitability of brightness as a quantity for illuminating engineering specifications. On Wednesday afternoon, in a paper "Two Frontiers of the Lighting Art," Mr. H. L. Logan discussed criteria for artificial lighting derived from a study of light distribution in natural fields of view. He went on to explain the use of these criteria in design procedure, including the use of environmental colour in engineering, and showed how these ideas could be applied to the design of lighting fittings and the attainment of standards of visual comfort. On Thursday morning W. D. Chesterman and J. B. Collins presented a paper on "The Problems of Underwater Illumination," discussing the optical properties of the ocean—particularly attenuation of light, scatter function, spectral transmission and polarisation effects. The authors reviewed some of the regional variations of water opacity and showed how underwater cine-film technique facilitates the exact study of visibility under daylight conditions. After the annual general meeting of the Society on Thursday afternoon, there was an address on "Comfortable Lighting," by L. C. Kalff, who suggested that every visual task presents a pattern of lines, colours and brightnesses and that, for "comfortable seeing" there are certain preferable arrangements of these three elements in relation to the three major parts of the visual field—namely, the visual task, the immediate surroundings and the background. To-day's session (Friday, May 23rd) begins with a paper by Anthony Pott on "Lighting in the Design of Schools." This afternoon L. H. Hubble will read a paper on "The Design of Interior Lighting Equipment."

Gas Blast Circuit Breakers*

RECORDING OF CURRENT IN A.C. POWER ARCS NEAR CURRENT ZERO

BY F. O. MASON, B.Sc. (Eng.), A.M.I.E.E.

SUMMARY

THIS article is mainly concerned with the problem of recording the currents around the current zero period associated with arcs drawn in circuit breakers.

Various methods of recording these currents are discussed and the particular method of recording current by amplifying the voltage drop across a low value resistive element in series with the circuit in which current is to be measured is treated in some detail.

Misleading results which might be obtained from deficiencies in the design of the recording equipment are illustrated, whilst sources of error and requirements of the apparatus necessary to avoid these are considered.

Some preliminary results made on a 1000A (r.m.s.), 6600V scale, using the method particularised above, have been made, and show that the current pauses around zero for a time of the order of 5 to 10 microseconds before the arc restrikes and power current flows again. Measurement of arc resistance from these records indicates that the arc resistance increases rapidly before current zero, the rate and time of increase being virtually the same whether the circuit is energised from a discharging condenser or generator, or whether the arc restrikes or not.

The records also indicate instability in the arc as the current approaches zero, and a current pulse corresponding to the arc restriking.

INTRODUCTION

The recording of current in connection with circuit breaker operation has, in the past, been mainly confined to determining peak and r.m.s. values, and in general the recording has been made on a comparatively slow time scale such as is obtained when electromagnetic oscillographs are used.

Present-day knowledge of the action of gas blast breakers, however, makes it apparent that current as usually recorded does not give all the information required for modern studies of arcing phenomena, since, as has been indicated,[1] the conditions obtaining in a gas blast breaker close to current zero, are those which will ultimately determine whether the breaker will or will not clear the circuit.

Much information is available concerning the voltage which appears across an arc during this period, but little is available on the current, although there is much evidence to show that the arc current does not always pass through zero in a simple sinusoidal form. The lack of information in this direction is largely due to recording difficulties, and the main object of this article is to discuss generally the various methods which may be adopted for recording the currents in question, the problems so involved, and, in particular, to describe a method in which current is measured by amplifying the voltage drop across a low value resistive element in series with the circuit carrying the current to be recorded.

Some results using the above method are given of tests made on a 1000A (r.m.s.), 6600V (r.m.s.) scale.

METHODS OF OBTAINING CURRENT VALUES

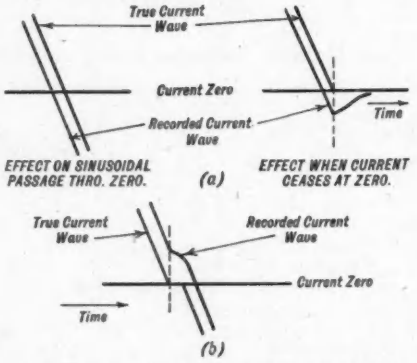
There are several methods by which the currents referred to above may be obtained, some direct and others indirect. One indirect method is to measure both arc volts and voltage drop across a series reactor and then by calculation from the known constants of the circuit obtain values for current. This is a long process and requires many hours of work to obtain values for one test; nevertheless, successful results have been obtained by the E.R.A. Measurement of the decrement of the oscillatory component of the recovery volts is another indirect method which, from calculation, yields values of current after current zero.

However, there are three main ways whereby the small current values around current zero can be obtained more or less directly. They are:

(*a*) Measurement of arc resistance and voltage and computing the current therefrom.

(*b*) Using the magnetic field associated with a conductor carrying the current to be measured to deflect a cathode-ray oscillograph beam.

(*c*) Measuring the volts drop across a resistance in series with the current to be recorded.



(*a*) Effect of residual inductance in the resistive element.
(*b*) Effect of excessive shunt capacitance in amplifier.

FIG. 1—PHASE SHIFT DUE TO LIMITATIONS IN RECORDING APPARATUS

The first method has been used by the Electrical Research Association with some success,[2] although the measurement of current was incidental to the main object of the experiments, which was the measurement of arc resistance. This method—which obtains resistance by superposing a high-frequency current on the arc current and comparing the high-frequency voltage developed across the arc with that across a known series resistance—has two main drawbacks for general use. One is that the range of current that can be recorded accurately in a single test is limited and the other that the maximum rate of change of current is dependent on the frequency of the superposed high frequency. The higher the rates of change of current required to be recorded, the higher must be the frequency of the superposed high-frequency and frequencies much above a few hundred kilocycles are difficult to work with when associated with power circuits. However,

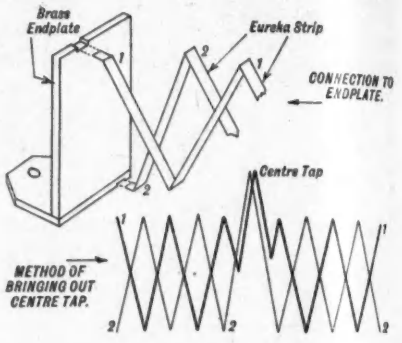


FIG. 3—DESIGN OF RESISTIVE ELEMENT

for certain conditions this method may still have its uses.

The second method has been given a good deal of attention by the E.R.A., as it offered certain advantages over others. It was hoped that ultimately, for heavy currents at least, it might have been possible to obtain satisfactory magnetic deflection of a cathode-ray beam simply by placing a cathode-ray tube in close proximity to a conductor carrying the current to be recorded, and thus eliminating modifications to the circuit. In the initial stages of development, the magnetic field was obtained by passing the current to be recorded through coils surrounding the cathode-ray tube. The coils were connected in series with the main circuit but had an inductance low compared with that in the main circuit.

A certain amount of success of a qualitative nature has been obtained using this method, but it became obvious that some distortion due to time lag in the recording was making the results open to doubt where accurate quantitative results were required. The cause of this distortion was finally traced to the presence of the electrode system of the cathode-ray tube. Apparently, the high magnetic fields associated with the main current period, induced lagging fields in the slightly magnetic electrode system of the tube, so that the resulting field deflecting the cathode-ray beam at current zero lagged the field produced by the current flowing in the deflecting coils.

To avoid this trouble methods were

KEY.

	Resistors	
*R*1, *R*2	1500Ω	
*R*3	55Ω	
*R*4	500Ω	(var.)
*R*5, *R*6	2000Ω	
*R*7, *R*8	7000Ω	
*R*9	3.000Ω	
*R*10	12.500Ω	
*R*11, *R*12	100,000Ω	
*R*13, *R*14	30,000Ω	

	Valves	
*V*1, *V*2	Mazda	*SP*41
*V*3, *V*4	Mullard	*EL*32
*V*5, *V*6	Mullard	*EL*32

All resistors are of high-stability carbon

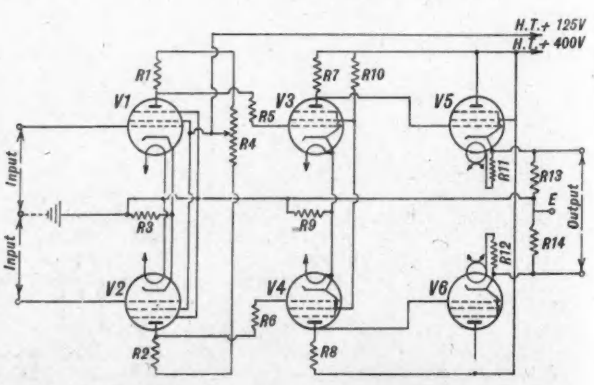


FIG. 2—PUSH-PULL AMPLIFIER FOR PRELIMINARY TESTS

* Based on report Ref. G XT132 of the British Electrical and Allied Industries Research Association.

considered whereby the current during the main part of the half-cycle was by-passed or balanced out from the deflecting coils. After some consideration of the various methods by which this object might be obtained, it was realised that further detailed experimental evidence would be required to ensure that such artifices would have negligible effects during the current zero period, and in view of this, and other factors, the method was not pursued.

There are two approaches to the third method. One is to use a low value of resistive element and to amplify the volts developed across it, using some means to prevent the excessive voltages developed during the main current period from damaging the

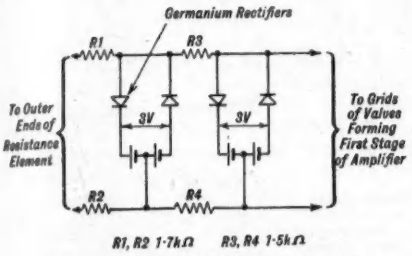


FIG. 4—VOLTAGE LIMITING CIRCUIT

amplifier. The other is to use a high value of resistive element which is shorted out during the main current flow and only comes into the circuit during the current zero period. The second approach, which requires no amplifier, but only gives values of current after current zero, has been used by Bronstein.[3] Briefly, the method is as follows.

Inserted in the circuit in which current is to be recorded is a resistance of high value, such that the currents to be recorded produce across it voltages of sufficient magnitude to be applied directly to the deflection plates of a cathode-ray tube. During the main current flow, the resistance is shorted out by ignitrons (one for each polarity). When the current passes through zero, the ignitrons are extinguished, leaving any post-arc current to flow through the resistance. The soundness of this method depends not only on the arc resistance at current zero being high compared with that of the series resistive element, but also on the accuracy of the assumption that it would have remained high had the resistance not been inserted.

In view, therefore, of the limitations mentioned above, and of the fact that it is rather complicated and tends to become unwieldy at high currents, the method to be described using a low value resistive element and an amplifier, is to be preferred as being without these limitations, and much more compact.

USE OF LOW VALUE RESISTIVE ELEMENT WITH AMPLIFIER

General.—This method uses apparatus which can be broadly divided into three parts :—

(i) The resistive element which is connected in series with the circuit in which current is to be measured, and across which is developed a voltage proportional to the current.

(ii) An electronic thermionic valve amplifier for amplifying the voltage recorded across the resistive element, together with its power supply and cathode-ray tube for displaying the amplified voltage.

(iii) A special circuit arrangement to prevent the high voltages developed across the resistive element during the main current carrying period, from damaging the amplifying equipment or introducing distortion.

This latter arrangement, which limits the voltage applied to the amplifier, will be referred to as a " voltage limiter."

Resistive Element.—The resistive element requires very careful attention as it is probably that component in the chain of apparatus whose requirements, for the present purpose, are likely to be most difficult to meet. It is essential that the residual inductance of the element should be as low as possible. If, for example, the time scale of the recording is such as to allow a discrimination in time of the order of one microsecond, then, for the voltage developed across the element not to lead the current by an appreciable amount, the phase relationship, in time, between the current in the element and the voltage developed across it should be less than one microsecond.

Now, in the present case, for symmetrical currents the fundamental frequency is 50 c/s, and therefore at this frequency the phase shift in degrees should be less than

$50 \times 360 \times 10^{-6}$ deg. $= 0{\cdot}18$ deg., or approximately $1{\cdot}0$ minute.

Now, to avoid any material change in main circuit constants the resistance of the element should not, say, be more than 1/20th of the circuit resistance, in the present case $0{\cdot}1$ ohm, and thus to limit the phase shift at 50 c/s to 1 minute, the residual inductance of the element should be less than $0{\cdot}1$ microhenry. The phase shift in time varies little with frequency until the frequency reaches some hundreds of kilocycles per second, when it gets progressively smaller as the frequency increases. However, in addition to phase shift, residual inductance will give rise to frequency distortion, since as the frequency increases the effective impedance of the resistive element and consequently the voltage developed across it will increase, and thus tend to accentuate fast changes in current.

Under transient conditions the effect of residual inductance in the resistive element

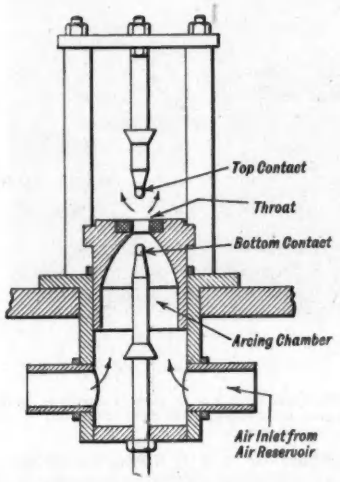


FIG. 5—DIAGRAM OF SINGLE AXIAL GAS BLAST BREAKER

is likely to give very misleading results. For instance, referring to Fig. 1*a*, it will be seen that when recording a simple sinusoidal current, the effect is merely to show the recorded current leading the true current trace, i.e., leading that voltage which would have obtained across the element had there been no residual inductance. This effect, if there were no fiducial time mark to judge from, would undoubtedly pass unnoticed.

However, if the current through the element ceases at zero, the effect will be that of Fig. 1*a* (right). The apparent current will die away with a time constant L/R at the instant the actual current ceases—where R and L are the resistance and inductance respectively of the element—and may well be mistaken for post-arc current.

Careful consideration was therefore given to the resistive element and a satisfactory design produced which is shown in Fig. 3. The upper view shows schematically the resistive element in expanded form; it consists of " Eureka " strip, 1in wide and $0{\cdot}010$in thick, the dimensions being chosen to keep the element as compact as possible, whilst still being able to handle the test current without appreciable change in resistance due to heating. There are two elements, each approximately $0{\cdot}2$ ohm resistance, made by bending the strip back on

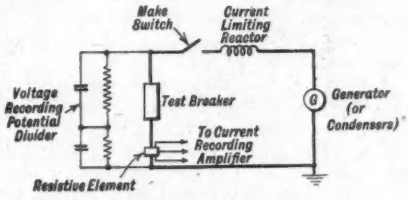


FIG. 6—TEST CIRCUIT

itself in the manner indicated, with the centre of each strip (one bent double in the centre) brought out to form a centre tap. Between each bend and between strip and end plates is a thin strip of mica, from one to two thousandths of an inch thick, for insulation.

The two strips are mounted in parallel, side by side, about ½in apart, between two copper end plates insulated one from the other, to which the ends of the strips are soldered, so that current in adjacent loops of the two strips will flow in opposite directions. A terminal soldered to each end plate forms the connection to the element for recording, whilst connections to the main circuit are made to brass lugs brazed to the end plates to ensure that any contact resistance at these points is not included in the resistance across which the voltage is to be measured. This element has been measured by the National Physical Laboratory, and shown to have a resistance of $0{\cdot}103$ ohm, and an inductance of $0{\cdot}007$ microhenry $\pm 0{\cdot}005$ microhenry, giving a time constant of approximately 7×10^{-6} seconds. This is well within the target value of $0{\cdot}1$ microhenry referred to above.

The effect of capacitance across the resistive element—which includes the leads therefrom—can be neglected, as it can be shown in the present case that the effect of the capacitances associated with the apparatus is small compared with the residual inductive effect.

Amplifier and Associated Equipment.—The requirements of the amplifier are to some extent determined by the recording system, the maximum output voltage required being determined by the cathode-ray tube used, and the upper frequency response by the time resolution of the recording. In the present case, a maximum output of about 300V peak to peak was required, whilst the frequency response up to about 1 or 2 Mc/s was considered adequate.

The input to the amplifier is, of course, determined by the maximum current to be recorded accurately, and for the initial recordings 10A was considered as a reasonable level, giving 1V across the resistive element.

The required response of the amplifier to low frequencies is determined by the necessity to keep the phase shift at, say, 50 c/s down to the limits expressed above concerning the resistive element, and to attain this it is necesary for the amplifier to be d.c. con-

nected. However, a d.c. connection does not in itself eliminate phase shift errors at the lower frequencies, and it is essential to avoid the use of capacitance in the form of cathode resistance by-pass capacitors, and resistance-capacitance h.t. decoupling. The use of capacitance in the latter way may result in the output lagging the input voltage, and giving the reverse effect to that of inductance in the resistive element. Fig. 1*b* is a diagram showing this effect when there is a discontinuity around current zero which, it will be seen, will tend to mask any post-arc current which may be present. In addition, if correlation were made correctly in time, the effect of the current lagging the arc volts would appear to give the arc the characteristics of an inductance. To avoid this form of error, a push-pull connection for the amplifier is preferable, with the amplifier fed from a low impedance stabilised power pack.

A design of amplifier, which was based on the above considerations, and was used in the tests described later, is given in Figs. 3 and 4. The power supply to the amplifier was obtained from a stabilised power pack of conventional design and, as a further aid to stability, the power pack was fed from the mains through a constant voltage transformer. Using the component values given, the amplifier had a gain of approximately 200 with 1V input, and a frequency response uniform up to about 300kc/s, falling by 6 db at 1 Mc/s. It will be appreciated, however, that, with 1000A (r.m.s.), say, in the test circuit during current peaks, voltages of the order of 140V would appear across the resistive element and, unless suitable steps were taken, would be likely to damage the amplifier. Moreover, it is fairly straightforward to calculate the response of the amplifier when working on the linear part of its characteristics, and thus obtain a good idea as to its likely behaviour, but if the valves in the amplifier run into saturation or complete cut-off, the effect in detail would be virtually incalculable particularly under transient conditions. It can, however, be established that under such conditions additional and appreciable distortion can occur, even when the input to the amplifier has returned to its normal level, particularly in the cathode follower stage.

To avoid this trouble a voltage limiter was introduced between the resistive element and the amplifier; it followed the circuit arrangement of Fig. 4. It consisted of a network of series resistances and shunt rectifiers, the latter being germanium rectifiers (B.T.H. type "CGI–C") and biassed from 1½V dry cells. Two stages of limiting were found necessary to keep the maximum input to the amplifier down to safe limits, without unduly affecting the frequency response of the equipment as a whole.

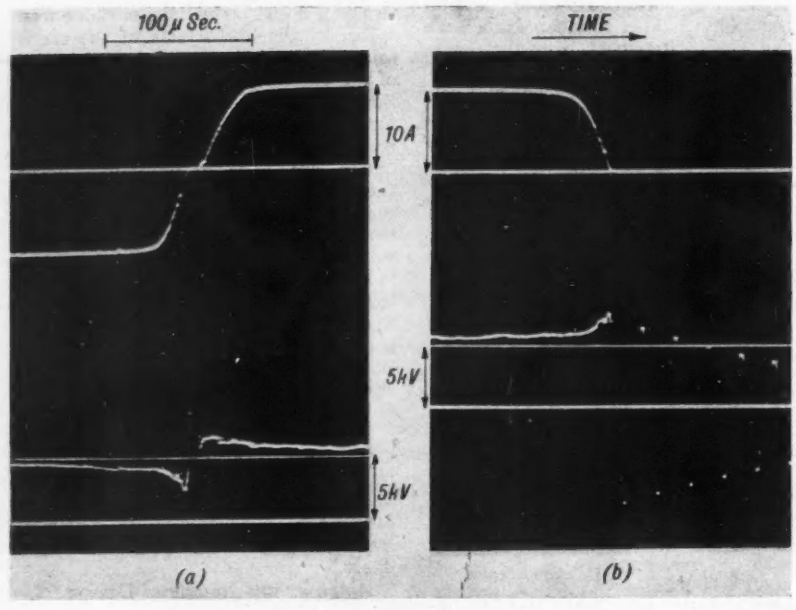
Test Results

A few preliminary tests using the apparatus described have been made on an experimental axial-flow gas blast breaker of the form indicated in Fig. 5, the total arc gap being 4cm, and the gas outlet 1cm or 1·5cm diameter. In these tests the arc was initiated by a fuse wire and records of current and voltage taken on a high-speed rotating drum camera photographing the display on a G.E.C. type "4504" cathode-ray tube. Voltage recording was obtained from a resistance-capacitance divider connected across the breaker.

Some of the tests were made with the circuit of Fig. 6 energised as shown from a generator excited to 6600V (r.m.s.), giving approximately 1000A (r.m.s.), whilst others were made with a similar circuit energised from a 5 micro-farad capacitor, charged to 8kV approximately, in place of the generator. In the latter case a damped oscillatory current is produced of about 500 c/s, giving a peak value of 140A in the first half-cycle, and a rate of change of current at current zero equal to that obtaining when the generator was used. These conditions have been shown[1] to give arcing conditions around current zero similar to those obtaining when the circuit is energised from the machine.

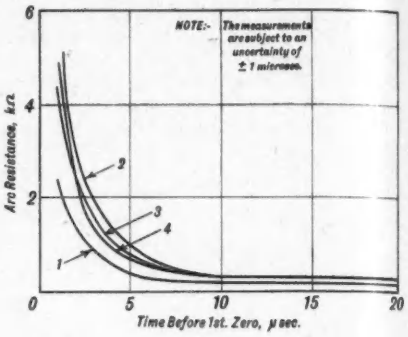
Fig. 7 is part of a record, enlarged and representative of all the tests made, which was obtained with the breaker of Fig. 5, operating in the circuit of Fig. 6 energised from capacitors, the initial gas (air) pressure in the arcing chamber being 50 lb per square inch gauge. Fig. 7*a* shows a current zero at which the breaker failed to clear the circuit, whilst Fig. 7*b* shows a part of the following half-cycle of current, at the end of which the breaker cleared the circuit.

In Fig. 7*a* a pause in the current trace



Oscillograms:
(*a*) First current zero: breaker fails to clear circuit.
(*b*) Second current zero: breaker clears circuit.

FIG. 7—OSCILLOGRAMS OBTAINED WITH TEST CIRCUIT OF FIG. 6, CAPACITOR FED



Test No. 1	
Energy source	10MW generator
Peak current	1500A
No. of half-cycles of arcing	One (30 c/s)
Throat diameter	1·5cm
Initial reservoir pressure	65 lb per sq in
Test No. 2	
Energy source	5μF capacitor
Peak current	140A
No. of half-cycles of arcing	Two (500 c/s)
Throat diameter	1·5cm
Initial reservoir pressure	75 lb per sq in
Test No. 3	
Energy source	5μF capacitor
Peak current	140A
No. of half-cycles of arcing	One (500 c/s)
Throat diameter	1·5cm
Initial reservoir pressure	75 lb per sq in
Test No. 4	
Energy source	5μF capacitor
Peak current	140A
No. of half-cycles of arcing	Two (500 c/s)
Throat diameter	1·0cm
Initial reservoir pressure	95 lb per sq in

FIG. 8—ARC RESISTANCE BEFORE FIRST CURRENT ZERO

lasting for about 10 micro-seconds during the rise in restriking voltage,† before breakdown, is clearly shown. Whether the current is entirely zero during this period cannot be decided from these records, but the deflection scale is such as to indicate that the current is less than, say, 250mA.

It will also be noted from Fig. 7*a* that the current tends to rise abruptly at first after the zero pause at a time corresponding to that of voltage breakdown, and indicates a pulse of current immediately preceding the normal rise of current. The presence of a current pulse at about this time has been observed in photographic records taken by the E.R.A.[5] on a rotating drum camera, and also by observers in Japan.[6]

A further point of interest is to be seen in the current trace as it approaches zero. It indicates small fast current changes, which in a general way correspond with sudden voltage changes shown on the voltage trace. Although the scale of recording does not permit these fluctuations to be resolved in detail, they do indicate a condition of instability in the arc.

Values for arc resistance as the current approaches zero (smoothing out the small fluctuations) have been measured, and representative curves obtained from tests made under differing conditions are given in Fig. 8. Bearing in mind the time discrimination of the recordings—not less than a microsecond—it will be seen that there is little difference between the curves obtained with the

† It should be pointed out that although the traces of voltage rises after current zero can be seen on the original negatives, it has been found advantageous to touch them up for reproduction purposes.

generator and those obtained using the capacitors, whether preceding a clearance or a failure. The arc resistance is generally of exponential form, rising most steeply from about 400 ohms at 5 microseconds before zero to approximately 5000 ohms at 1 microsecond before zero. Beyond this time no reliable value of resistance could be obtained, but it appears to be increasing with the same general characteristic. Further, although it would be unwise to draw any definite general conclusions from the few tests so far made, particularly as the high-frequency small current fluctuations are not resolved, the similarity between the arc resistance curves preceding zero for both clearances and failures would tend to indicate that those conditions ultimately determining whether the breaker will clear or not[4] are likely to be those obtaining either extremely close to zero or after.

It is of interest to note that the results of arc resistance given here are in a general way similar to those obtained by the method of superposing a high frequency oscillation on the arc described earlier[2], the time before zero at which arc resistance increases and the rate at which it increases being alike where the conditions of test were comparable.

Conclusions

Apparatus.—It is considered that, at present, the most flexible method of recording the currents obtaining around the current zero period, in a circuit breaker arc, is to use a low-value resistive element in series with the circuit in which current is to be measured, and amplify the voltage developed across it. The main requirements for the successful operation of the method are :—

(1) The residual inductance of the resistive element should be kept to a minimum.

(2) The amplifier should be of the d.c. push-pull type.

(3) To reduce undesirable distortion, and possible damage to the amplifier during the main part of the current wave, it is necessary to limit the voltage applied to the amplifier input during this period.

Test Results.—The salient features of test results obtained under the conditions of test described in the body of the report, using the method outlined above, can be summed up as follows :—

(1) Tests made on a gas-blast circuit breaker in a circuit energised either by a generator or capacitors show that there is a pause in the current wave of about 5 to 10 microseconds after the current reaches zero and before the arc re-strikes and current flows again.

(2) Current, if any, flowing through the arc gap during this pause is less than 250mA.

(3) There are indications of instability in the arc as the current wave approaches zero. A short current pulse corresponding to the arc re-striking precedes the normal current flow.

(4) Measurements of arc resistance to within 1 microsecond of zero, show it increasing before current zero : from this aspect there is no significant difference between tests made with the generator or capacitors, and whether the arc re-strikes or does not re-strike at zero is immaterial.

Supplementary Report

To supplement the work described above records have been made of current and voltage during the current-zero period in circuit-breaker arcs, over a period of some 50μ secs. The apparatus and techniques employed to obtain the oscillograms of Fig. 9 were essentially the same as already described, except that a swept time scale has been used in place of the rotating drum ; this method gives more detail of the current-zero phenomena and enables currents down to about 100mA to be read. The records were obtained on the same experimental gas blast circuit-breaker and condenser discharge circuit, the currents and voltages, in the circuit at current-zero being equivalent to those obtained on a 1000 r.m.s. ampere circuit at 50 c/s, at a voltage of 6·6kV.

The upper curves (Fig. 9) show oscillographic records of the current and voltage obtained with 50 lb. per square inch air pressure in the arcing chamber, and show the circuit being cleared. The current comes down to zero and remains there, whilst the voltage shows the initial rise to the restriking voltage.

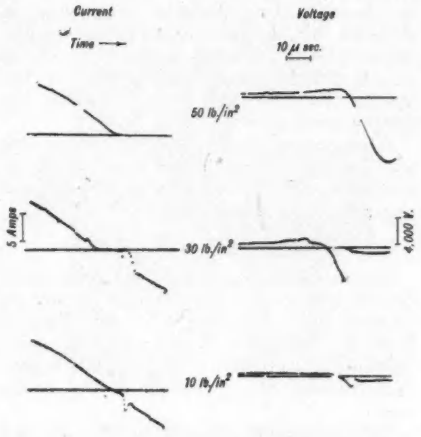


FIG. 9—CURRENT AND VOLTAGE RECORDS AT DIFFERENT PRESSURES

The middle curves, taken with 30 lb per square inch air pressure, show the arc restriking at the current zero with a very fast voltage breakdown. The current comes down to zero, stays there for a period of about 4 to 5μ secs., rising slightly, just before the gap finally breaks down. At the instant of breakdown there is, with this fast breakdown, a certain amount of indirect pick-up from the circuit into the amplifier, and thus the form of current during and immediately following the fast breakdown shown on this current oscillogram suffers some distortion.

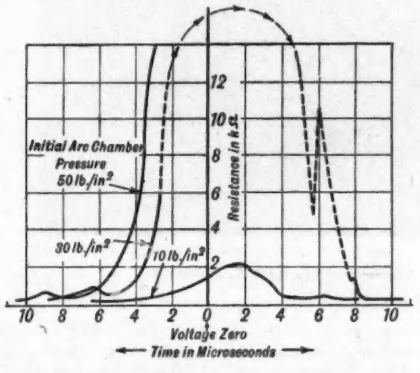


FIG. 10—ARC RESISTANCE AT DIFFERENT PRESSURES

The third set of records taken with 10 lb per square inch in the reservoir, that is, at a pressure which, in this case, is not sufficient to give the velocity of sound in the throat, shows little or no current pause at zero. There is, however, a small current pulse coinciding with arc re-ignition. The voltage record shows the rate of rise of voltage after voltage zero, much reduced as compared with the other two records, with the arc re-igniting without the fast breakdown shown in the previous record.

The small gaps in the current and voltage traces were deliberately introduced by demodulating the beams of the two C.R.O. tubes, from a voltage pulse operating on both tubes simultaneously. By this method the records may be lined up very accurately in time and values of arc resistance may be determined.

Fig. 10 shows values of arc resistance plotted against time. The full lines in this figure are actual values obtained from the records of Fig. 9, the dotted lines merely serving as an indication so that the records can be followed through the period of no current when values of resistance cannot be measured.

Although, in a general way, as the air pressure is increased the arc-resistance begins to increase a little earlier before the voltage zero, and to increase more rapidly, this is not always the case. For instance, when the circuit breaker is operating under conditions where it may or may not clear the circuit at the end of the first half-cycle of arcing, it does not follow that the arc-resistance during a clearance will always begin to increase earlier or at a faster rate than the resistance in a test which fails to clear the circuit. This fact is instanced in the arc-resistance measurements shown earlier in this article.

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[1] "Severity of Circuit Breaker Test Conditions," by F. O. Mason, THE ENGINEER, 187, 420 (April 15, 1949).

[2] "Impulse Voltage Injection : Injection Into an Arc Gap Near Zero Current," by A. M. Cassie, F. O. Mason and L. H. Orton, *Electrician*, 123, 841 (June 30, 1939).

[3] "The Resistance of an Arc Gap During the Process of Voltage Recovery," by A. M. Bronstein, *Elektrichestvo*, No. 4, 39–45 (April, 1949).

[4] "Gas Blast Circuit Breakers : Behaviour of Experimental Models at Reduced Pressures," by F. O. Mason, L. H. Orton and A. M. Cassie, THE ENGINEER, 188, 630–633 (December 2, 1949).

[5] "Gas Blast Circuit Breakers : A Preliminary Study of Arc Form and Movement in a Single Axial Blast Experimental Model," by F. O. Mason, *Engineering*, 172, 711–713 (December 7, 1951) and 743–745 (December 14, 1951).

[6] "Study of Extinction and Re-Ignition of Air Blast Arcs by a Simplified Boys Camera," *E.T.J.*, November, 1939, page 260.

B.C.U.R.A. Annual Luncheon

OVER 300 members and their guests attended the annual luncheon of the British Coal Utilisation Research Association, which was held on Wednesday last at the Savoy Hotel, London. The Right Honourable Geoffrey Lloyd, P.C., M.P., the Minister of Fuel and Power, proposed "The Association," in which he discussed scientists generally and felt that one of the real problems of the day was the increasing degree of specialisation. This tendency incurred certain dangers, such as the possibilities of an unbalanced personality and, to counterbalance this the Minister thought that there was need for a wider consideration of the humanities by studying the early history of science. Sir Charles Ellis, the president, replied and stressed the need for the promotion of the proper utilisation of fuel and the part played by research in the modern industrial world. Representatives of the Government and of privately and publicly owned corporations were members of the Association, and the four nationalised bodies were collaborating with private enterprise in support of the Association's studies of fundamentals. Continuing, Sir Charles said that efforts were mainly directed to practical matters and that good progress was being made now and was hoped for in the future. The attitude of mind to research was never just a matter of the slide rule, but an expression of artistic appreciation. The president concluded by mentioning that the inaugural Coal Science Lecture would be given by Sir Alfred Egerton that afternoon in the apartments of the Royal Society and by presenting the Coal Science Medal to Sir Alfred. Sir John Charrington, proposed the toast of "The Guests," and Viscount Waverley responded.

British Industries Fair

No. IV—(*Continued from page 657, May 16th*)

IN the following paragraphs we continue our description of some of the engineering exhibits at the Castle Bromwich section of the Fair which closed on Friday, May 16th.

T. and T. Works, Ltd.

A mobile self-loading elevator suitable for handling a variety of materials has been developed by T. and T. Works, Ltd., Billedon, Leicester, and can be fitted to most makes of tractors. This machine, known as the "Autoloader," can be seen in operation in Fig. 43. In the exhibition it is fitted to a Ferguson tractor and is driven from the power take-off.

The loader consists of a rigid fabricated superstructure bolted to the tractor and having at its rear a bucket elevator, at the foot of which is a steel scoop or boot, which is backed into the heap of material to be loaded. Material from the heap is picked up and thrown into the elevator scoop by rotating archimedean screws with serrated edges. The elevator buckets pick up the material from the scoop and deliver it into a discharge chute at the top of the boom.

From this discharge chute the material drops into a troughed belt conveyor supported on a rotating head on the superstructure of the machine. This conveyor, through a hand-operated gear, can be turned through about 180 deg. to deliver at an angle of up to 90 deg. on either side of the machine. The height at which the conveyor delivers material and the wide angle over which it operates makes the machine particularly suitable for loading lorries or elevated hoppers from dumps at road level.

FIG. 43—MOBILE SELF-LOADING ELEVATOR—T. AND T. WORKS

McKenzie and Brown, Ltd.

On one of the outdoor stands swinging or oscillating conveyors of Continental design, now being made in this country by McKenzie and Brown, Ltd., of St. Helen's Road, Caernarvon, were to be seen in operation. These conveyors are designed for transporting and screening a variety of materials such as sand, stones, coal slag, cement, ore, &c.

Each machine consists of two main parts, which can be in the form of troughs or tubes, placed one above the other and connected by flat steel springs. An eccentric drive imparts reciprocating motion to the parts and full equilibrium of all forces acting on the oscillating parts of a machine is obtained by the use of balancing weights. Material being conveyed moves forwards in a series of short jumps and according to the makers has no abrasive action on the bottom plates of a conveyor.

When the machines are used for screening a series of screening or perforated plates are inserted in the conveyor frame to grade the material as it passes along.

Bastian and Allen, Ltd.

Several steam and hot water electrode boilers were displayed upon the stand of Bastian and Allen, Ltd., Ferndale Terrace, Harrow, Middlesex, and a 70kW boiler working in conjunction with a unit heater, demonstrated the operation of the equipment.

New equipment introduced by this firm included the "Speedylectric" mobile steam jet cleaner shown in Fig. 44, designed for removing grime, grease, &c., with a high velocity jet of dry steam and detergent. This unit is rated at 20kW on 400/440V, three-phase, 50 c/s supplies and is suitable for a steam working pressure of 150 lb per square inch.

The cleaner has a vertical boiler in which cast iron alloy electrodes are supported from porcelain bushings sealed into metal flanges. A balancing tank of similar construction to the boiler and a 15 gallons capacity water supply tank are also incorporated in the unit. The single-acting reciprocating feed pump of the set is directly coupled through an enclosed oil-immersed reduction gear to a three-phase electric motor. As can be seen from the illustration, all of the controls are grouped on the front panel of the unit and they include a hand operated triple-pole switch, a pump motor starter, an ammeter, and a plug socket for connection to the power supply. The steam cleaning lance has a built-in injector for detergent and it is coupled to the unit by twenty yards of flexible hose.

The cleaner operates on an all-electric principle with automatic balanced control, which adjusts the electrical input to match the steam demand. When the boiler is at full pressure and no steam is being used, no current is taken. As the pressure drops slightly when steam is taken the electrical loading builds up to meet the demand and this cycle is continuous whilst the cleaner is in use.

FIG. 44—MOBILE STEAM JET CLEANER—BASTIAN AND ALLEN

In operation steam generated in the boiler shell by the resistance of water to current passing between the electrodes passes through the main steam pipe and also through a header pipe into a regulating or balancing tank. As the preset steam pressure of 150 lb per square inch is reached, a steam regulating valve closes and cuts off supply to the balancing tank. Steam generation continues and produces a higher pressure in the boiler. At the same time, the pressure in the balancing tank falls as steam condenses; the pressure in the boiler then forces water through a common connecting pipe and causes the level of the water in the balancing tank to rise and the level of the water in the boiler to fall. As the water level in the boiler falls, the electrodes are gradually uncovered. The current taken is proportional to the immersed area of the electrodes and the gradual reduction in water level reduces the current input, slows down the rate of steam generation, and reduces the pressure. As the pressure falls the regulator valve opens and steam again passes into the balancing tank and forces the water to flow back into the boiler. The water levels in the boiler and balancing tank do not equalise, but reach a balanced condition so that the electrodes are immersed sufficiently to provide adequate steam to supply the load and maintain the desired pressure.

When the boiler is up to pressure, steam is taken from it through the hose to the lance, which has two valves, one for steam and the other for detergent. By first opening the steam valve and then the detergent valve, detergent is drawn from a separate tank. The operator, through the valves, has fingertip control and can vary the steam and detergent supplies, according to the nature of the job he is cleaning.

Another exhibit was a 30kW electrode hot water boiler arranged in conjunction

with an electrode steam boiler to demonstrate the firm's method of peak load control. In it the controls are so arranged that when both units are in operation the total load will not exceed a predetermined demand. The steam boiler only takes the surplus load and when the hot water boiler is switched off the steam unit takes the whole of the load. This method of control is considered to be of special interest to large users of electricity in factories and mills, particularly where surplus load is available at certain times during the day.

Varatio-Strateline Gears, Ltd.

A new model of the "Strateline" speed-reducing gear unit, which is arranged for vertical mounting, was exhibited this year on the stand of Varatio-Strateline Gears, Ltd., 278, Aberdeen Avenue, Trading Estate, Slough. This new unit operates on the same principle as the firm's standard models

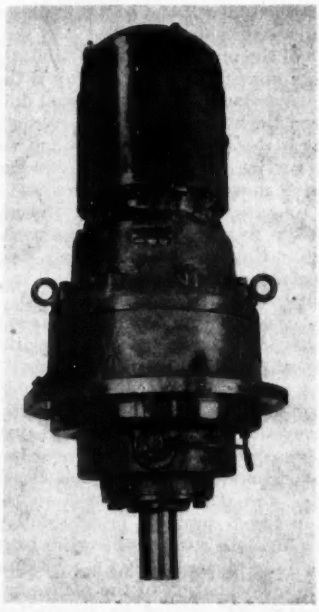

Fig. 45—Speed Reducing Unit for Vertical Mounting—Varatio

and, like them, has its input and output shafts arranged co-axially. It is particularly intended for driving mixing machines, agitators, &c., where vertical mounting is required and full advantage can be taken of the small headroom it requires when directly coupled to a driving motor.

Reduction units of this design are available from 2 to 12 h.p., according to input speed and reduction, and can give any reduction between 20 to 1 and 100 to 1, with a maximum torque of 16,000 lb-in for an input of 5 h.p. at 750 r.p.m. The unit illustrated in Fig. 45 has a reduction of 33 to 1 and, driven by a 7½ h.p., 960 r.p.m. motor, has a torque output of 13,000 lb-in. Together with its motor it is 3ft 6in high and under 24in in diameter.

Also to be seen upon this stand was a selection of the range of Blackheart malleable iron castings made by Follsain-Wycliffe Foundries, Ltd., of Lutterworth, near Rugby. This firm makes a wide variety of castings specially intended for use where it is required to resist shock, heat or wear.

Johnson and Phillips, Ltd.

Among the new products shown by Johnson and Phillips, Ltd., Charlton, London, S.E.7, were examples of the company's "Trinal" range of interchangeable circuit breakers and oil switches. The single-break arc-controlled "Trinal" oil circuit breaker (Fig. 46) has an A.S.T.A. rating of 250MVA at 6·6kV and 11kV; it was shown in a standard metalclad housing. The plain break "Trinal" circuit breaker (Fig. 47) is A.S.T.A. certified for 150MVA at 6·6kV and 11kV, 100MVA at 3·3kV and 37·5MVA at 0·8kV, and was in an air insulated metalclad housing. Finally, the

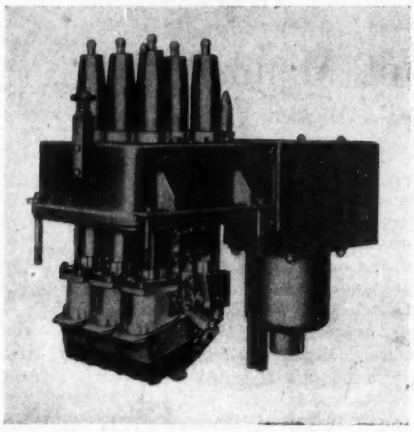

Fig. 46—"Trinal" Single Break Oil Circuit Breaker—Johnson and Phillips

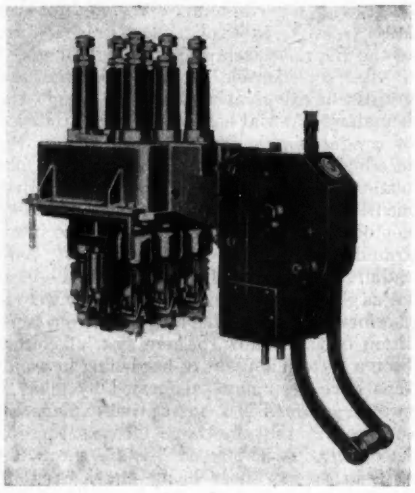

Fig. 47—"Trinal" Plain Break Oil Circuit Breaker—Johnson and Phillips

"Trinal" oil switch, which is designed for use in situations where automatic operation under fault conditions is not required, was exhibited in a housing of the same size as the metalclad units, to facilitate replacement in a switchboard if that becomes necessary. All "Trinal" units have similar dimensions and common fixings so that each unit can be accommodated and, if necessary, interchanged in standard Johnson and Phillips housings. Thus the growth of a system is unlikely to make a whole switchboard redundant; indeed, in many cases the board can be uprated by the substitution of a circuit breaker with a higher capacity rating.

Foster, Yates and Thom, Ltd.

There were many points of interest in a new 50-ton fully-automatic plastic press shown in operation by Foster, Yates and Thom, Ltd., of Blackburn. This machine (see Fig. 48) is designed to mould up to six articles having a total volume of 24 cubic inches at each pressing and it is a completely self-contained unit. As with the other "Lancastrian" presses made by the firm, it has a fabricated steel frame within which is enclosed the pumping unit and all the automatic controls and connecting piping.

The machine is fitted with an "Electraulic" axial plunger hydraulic pump, and its 50-ton, 12in stroke main ram has an approach speed of 5in per second, the pressing speed being adjustable between 0·27in and 0·05in per second. The 5-ton return ram has a speed of 2·8in per second, and there is a 6-ton top ejector ram with a speed of 2·1in per second, and a 9-ton bottom ejector ram with a speed of 1·9in per second.

The usable tool area is 24in by 12in, and, as already mentioned, from one to six impressions can be made per machine cycle using up to a maximum of 4 cubic inches of loose powder from each of six feeds. Two or more feeds can be coupled together for producing mouldings greater than 4 cubic inches volume and up to the maximum of

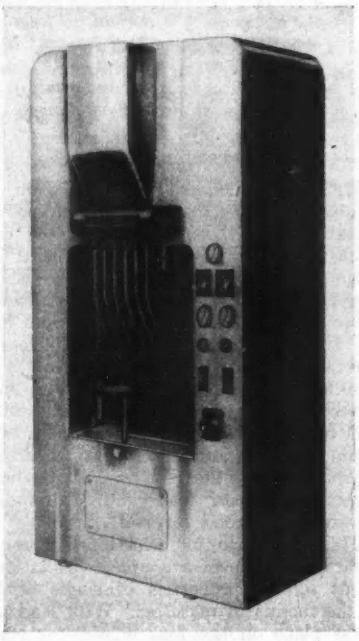

Fig. 48—Automatic Plastic Moulding Press—Foster Yates and Thom

24 cubic inches. A hopper of 4800 cubic inches capacity is fitted and it provides sufficient storage for ten hours' continuous operation. Below this hopper is a line of powder measuring cylinders, each of which can be individually adjusted to give the required feed volume without removing any component parts.

In the cycle of operations the outlets of the flexible plastic feed tubes leading down from the feed hopper are swung in by a bar to register over the mould cavities. The preset amount of powder is then ejected from the metering cylinders in the feed unit and drops through the tubes into the cavities. As the feed tubes are then withdrawn the press closes for the moulding and curing period. If necessary, a breathing period can be introduced and set for any required time. At the end of the curing time the mould automatically opens and the bottom ram ejects the mouldings. As the mouldings rise out of the cavities an air-cylinder-operated arm at the front of the mould sweeps forward across the mould and pushes the components into a hopper at the rear. A series of air jets from the arm come into effect at the same time to blow away any flash left in the mould. As this ejector and cleaning arm returns to its position of

rest, the feed tubes move forward to restart the cycle.

The mouldings ejected to the rear of the machine fall on to an automatic scale plate which checks their weight. If this weight is correct the plate tips for the components to fall down a chute out of the side of the machine, and the machine is reset for the next operating cycle to begin. If the weight is incorrect an alarm bell rings and the necessary adjustments can be made before the production cycle is re-started by the operator. The machine is completely interlocked so that the ram cannot descend until the mould-ejection arm and the feed tubes are clear of its opening, and each operation must be completed before the next one begins.

(*To be continued*)

The Flow of Metals

By PROFESSOR E. N. da C. ANDRADE, F.R.S.

No. II—(*Continued from page 659, May 16th*)

In this the sixth Hatfield Memorial Lecture, presented before the Iron and Steel Institute on April 30th, the author reviews knowledge about the creep of metals under stress. The metals concerned are lead, tin, copper, iron, cadmium and solid mercury. It is shown that the creep behaviour of all these and many other materials is very similar if allowance is made for temperature and can be expressed (if measured as the extension of a normal polycrystalline wire under constant stress) by the simple equation $l=l_o(1+\beta t^{\frac{1}{3}})e^{\kappa t}$, *where* t *is the temperature. The relative importance of* l_o, β *and* κ *varies markedly with temperature. The remainder of the lecture discusses this experimentally derived result in an endeavour to express what may be the underlying physical mechanism of creep.*

Reversed Shear

THE results under reversed shear are also surprising and show a marked contrast between the behaviour of the cubic metal lead and the hexagonal metal cadmium. No such contrast has ever been found in tensile tests. Both leads show in reverse a flow linear with time, there being no significant recrystallisation effects in reversed shear with the pure lead. The pure lead, however, behaves as a very much softer metal than it was before recrystallisation took place, as is to be expected. Cadmium, however, under reversed shear continues to obey the $t^{\frac{1}{3}}$ law, and the same contrast between lead and cadmium is shown on a second reversal.

This difference of behaviour in reverse shear is capable of a simple explanation in terms of the properties of single crystals of the metals in question. With lead glide takes place on the four octahedral planes, with three possible glide directions in each: with cadmium the one set of basal planes is operative, with three possible glide directions. Now the critical shear stress of lead single crystals† is about 14 grammes per square millimetre, as against about 50 grammes per square millimetre for standard cadmium, but lead, with the typical contrast between a cubic and a hexagonal metal, hardens very rapidly compared to cadmium, so that at 0·30 glide, for instance, the stress required to produce further glide is about 450 grammes per square millimetre for lead, as against 80 grammes per square millimetre for cadmium. The many glide possibilities which exist for a crystal grain in lead mean that the grain can adapt its shape readily to the complex system of stresses and strains produced by the movements of the surrounding grains: there is little geometrical hardening, but considerable physical hardening in the grains of the polycrystalline metal. With cadmium the limitation of glide to one plane means considerable geometrical hardening, even if we allow for twinning, but there is little physical hardening (see, e.g., Andrade and Roscoe, 1937). This geometrical adaptation explains how it is that lead (which in single crystal form is, after a few per cent glide, harder than cadmium), is in polycrystalline form so much softer, as measured by the value of B. It also explains why it is that, compared to cadmium, lead becomes progressively harder as deformation increases, hardness being for this purpose measured by $d\sigma/dB$, constant for lead but rapidly decreasing for cadmium. We do not yet know enough to explain the precise form of the B,σ relationship for the two metals.

After considerable forward shear the lead grains have greatly hardened and the boundary material has, owing to the rotation of crystal planes, been broken up, but the interlocking produced by the glide in four planes has prevented intergranular movement. When the shear is reversed glide does not occur in the hardened grains, but intergranular movement can take place. With cadmium, however, the crystal grains are, as far as glide is concerned, much as they were in the forward movement, and we have a repetition of the $t^{\frac{1}{3}}$ flow. There has, of course, been a certain amount of hardening in grains that have been much deformed by glide or twinning, which is a qualitative explanation of the fact that for large stresses there is hardening, as expressed by B, the value of B in reverse shear being smaller than B for large σ, although about the same for smaller σ. It is, of course, most desirable that a quantitative explanation of the variations of B with σ should be found, but this is not likely to eventuate until a convincing explanation of the $t^{\frac{1}{3}}$ law has been found. In those explanations so far put forward $t^{\frac{1}{3}}$ is introduced with one hand and deducted with the other.

If we express the flow of lead under reversed shear as

$$\gamma=A'+\kappa' t$$

then it is found that $\log \kappa'$ is linear with σ, just as $\log \kappa$ is linear with stress for creep under tensile stress. This supports the suggestion already put forward that we have here the same mechanism of movement in grain boundaries. In this reversed movement with lead we have pure linear flow with time, which gives us an opportunity of investigating in detail the variation of this flow with temperature and with impurities which segregate to the boundary.

Intragranular Glide

I have spoken of the β flow as connected with intragranular glide and its consequences, and of the permanent flow as due to the movement of grains conditioned by boundary effects; that is, as if the two effects were separate. Such a complete separation is not, however, physically possible. Glide and consequent rotation of the crystal planes within a grain is bound to modify the boundary, as I have illustrated with a model made of microscope slides; the coarser the glide packets the more the boundary is broken up.‡ On the other hand, the glide planes often do not run right to the crystal boundary (*cf.*, Boas and Hargreaves, 1948), which shows that the boundary has an effect on intragranular glide. The action of a given amount of glide in creating wider boundaries, mainly amorphous, will clearly be greatest when there is one set of glide planes only, as with hexagonal crystals, where we have also the possibility of twinning. I should like to be able here to develop the consideration of this interaction of the boundary and the intragranular glide so as to explain some of the problems offered by the variation of the constants B and β with stress, but I have not yet satisfied myself and so am unlikely to be able to satisfy you.

One of the problems posed by these experiments under simple shear is why is there no permanent flow. A great physical difference between the shear and the tensile method of testing is that in the tensile method we have a free surface which is under stress and continuously moving normal to itself and at the same time increasing in area. Under simple shear the free surfaces are unstressed and remain in the same plane as strain proceeds; the surfaces across which the stress is applied are not free, but lie in massive metal. In the tensile case the grains at the surface are free to move, in particular to rotate, relatively to one another, and this free movement at the surface promotes intragranular movement throughout the metal, with consequent adjustments, in the amorphous material, of the type discussed. In the shear case the crystal structure is locked at the edges of the annulus and deformations can, in the first case, proceed only by intragranular glide. Such glide both hardens the crystal structure in the glide planes and, as a consequence of change of inclination of the planes in neighbouring grains, creates amorphous material. Reversal of shear stress tears the grains apart, and we then, with hardened grains and an extended amorphous interlayer, have conditions for permanent flow.

That the free surface has an important influence in tensile experiments has been confirmed by some preliminary experiments of Dr. Kennedy and myself. We worked with lead to which 0·05 per cent tellurium had been added; with this metal there is no permanent flow except at the highest stress. The flow being thus characterised by β, we found the variation of β with stress for curves of four different diameters—1mm, 2mm, 3mm and 5mm—the grain diameter being about 0·2mm and so comparable with the wire diameter. At a given stress β was larger the smaller the diameter of the wire, which is what we should expect if there were a relatively weak surface layer. It was found that the results could be quantitatively expressed as

$$S=S_o\frac{(r-na)^2}{r^2},$$

where S is the value of the stress corresponding to a given value of β, S_o is the value towards which S tends as the radius of the wire becomes large, r is the radius, a the average grain diameter, and n a constant which turned out to be 0·3. This is equi-

† Unpublished experiments by Mr. M. J. Makin.

‡ If this picture is correct, the density of a fine-grained hexagonal metal should decrease appreciably on rapid extension, a matter for experimental investigation.

valent to taking a surface layer of about a third the grain diameter as having no strength at all, a crude representation of a weak surface layer of greater thickness. The formula represents the results very closely. Thus, at a particular value of β the stress S is 66·0kg, 72·25kg, 75·2kg and 77·3kg per square centimetre, from low to high diameter, while S_o comes out to be 82·1kg, 82·2kg, 81·8kg and 81·7kg, a very satisfactory constancy.

Some Practical Points

The general lesson for the practical man from the experiments under simple shear is that the type of creep that occurs depends essentially on the system of stressing; that, for instance, a marked permanent creep shown by tensile experiments may not occur at all when the metal is stressed so that the free surface remains in the same plane and of the same area, while the stress is entirely transmitted through massive metals. Further, that the creep under reversed shear stress may be essentially different from that under direct stress, as shown by the results on lead.

Perhaps I may here say a word on another aspect of creep which may be of interest to practical men, namely, creep under intermittent stressing, on which Dr. A. J. Kennedy has just completed an interesting study. I am afraid that the metal is our favourite polycrystalline lead, which offers a very favourable substance for study at atmospheric temperature. When such a metal is unloaded after a short period of creep it softens progressively, so that when it is restored it starts the new period of creep at a greater rate than that which prevailed just before unloading. Kennedy has worked out the creep under alternate periods of loading and unloading, which he has shown can be calculated in terms of one constant n in addition to β. What is surprising is that, within a certain range of ratio of on-and-off-lead periods the creep in the interrupted case, for a given total time, including the off-load periods, may exceed that for the same time under constant load.

Behaviour of Single Crystals

Before very briefly considering the theories that have been evolved, it might be well to consider the mechanical behaviour of single crystals of metal. In the first place, they are well known to be, in general, exceedingly soft and ductile. Strain takes place by glide on certain crystal planes in certain crystalline directions. With pure metals they begin to deform under tensile stresses of from 10 to 1000 grammes per square millimetre or so—about 14 lb to 140 lb per square inch—and harden considerably under strain, cubic crystals much more than hexagonal. Thus, copper, gold and silver (face-centred cubic) harden about eighty times (not 80 per cent) for 80 per cent glide, a glide which produces a hardening of about 30 per cent only for cadmium. This great softness, compared to ordinary metals, is explained by the well-established assumption that the structure of these crystals is not perfect, but contains places of misfit, or "dislocations," which travel under small stresses. The passage of a single dislocation leads to the displacement of the crystal to one side of its path relative to that to the other side of one atom spacing; the dislocation can be reflected when it reaches the surface and travel back, producing another unit displacement, and so on. The hardening I believe to be connected with the rotation of lattice fragments.

Not much has been done on the creep of single crystals under constant stress. Roscoe and I did a few experiments on cadmium, but the most systematic records are those of Cottrell and Aytekin, carried out at considerable stress. They found that the flow obeyed the equation,

$$\gamma=\gamma_o+\beta t^{\frac{1}{3}}+\kappa t$$

where γ is the total shear at time t, which is the form which my equation takes when shear, instead of extension, is in question.§ They also found that log κ was linear with stress, as in the tensile results. They further stress the point that I have already made, that the wide applicability of the $t^{\frac{1}{3}}$ law shows that the mechanism must be a simple and very general one.

It has been urged that the fact that there is a κ term in the creep of single crystals tends to invalidate the view that in polycrystalline creep the $t^{\frac{1}{3}}$ term is due to glide within the grains and the term to movement between the grains. However, in Cottrell and Aytekin's experiments the shear strains were very large compared to anything that takes place in the crystal grains of a polycrystalline metal: for shear strains less than 0·05 (3 deg.) the creep can be fitted by $t^{\frac{1}{3}}$ without any κ term. The κ flow can therefore be attributed to the large glide that takes place on certain slip planes when the glide is very large: no doubt on these planes the crystal structure is broken down and we are practically dealing with crystal boundary conditions.

When we consider the deformation of polycrystalline metals, one feature is the glide within the crystal grains, with the formation of slip bands, which we put down to the travel of dislocations either from the boundary or from near the boundary, since microscopic observation shows that the slip bands do not always extend right up to the crystal boundary (see, e.g., Boas and Hargreaves, 1948). There are probably strain centres of various degrees of gravity from which dislocations will start under different minimum local shearing stresses: we have seen that the course of β against stress is tolerably represented by $y=\kappa\int_o^x x^2e^{-x^3}dx$. The rotation of the glide planes in the grains, experimentally established by experiments of Chalmers and myself on the electric resistivity of metals during creep, must also play a part. However, until the t law has received a reasonable explanation the variation of β with stress is unlikely to be solved.

Between two crystal grains is a layer some atoms thick in which the atoms owe, in general, allegiance to neither crystal structure. Flow in these amorphous sheets takes place in the movement past one another, occassioned by thermal fluctuations, of atoms irregularly spaced. The behaviour of the boundaries is reminiscent of that of glasses as far as the effect of temperature is concerned, but, as regards stress, glasses behave as a true viscous liquid, the rate of flow at a given temperature being proportional to the stress. For all Newtonian liquids, including glasses, the activation energy is independent of the stress, which it cannot be for boundary flow in metals. By suitable assumptions concerning the activation energy required for an elementary rearrangement, the logarithmic relation between β and stress can be deduced (e.g., Dushman, Dunbar and Huthsteiner, 1944).

Attempts have been made to construct a theory of plastic flow on the basis of a suggestion put forward by R. Becker, that elementary increases in strain are produced by increases of local stress due to thermal agitation, the frequency of stress fluctuations which lead to such steps of strain being $\nu=e^{-A/\kappa T}$. This assumption does not lead to any decrease of rate of flow with time, that is, to a transient component of creep. Orowan, to whose constructive criticism the subject owes so much, has modified the theory, but we are still confronted by a relation of the type

$$\frac{d\gamma}{dt}=f(\gamma,\tau,T)$$

where γ is the strain, τ the stress and T the temperature.‖ Since metals are seldom, if ever, in thermal equilibrium with their surroundings such an equation of state cannot be valid. My own approach to the theory, to which I have alluded in discussing the variation of β, does not imply such a relation.

§ There is in this case nothing that corresponds to the increasing length of wire flowing which gives the exponential form in the tensile case.

Conclusion

My object has been to persuade you that there are certain simple laws which underlie the study of creep in metals and that a general explanation of many features of the process can be given in terms of the mechanical properties of the crystal grains and of their boundaries. We are, of course, a long way from the knowledge that will enable us to predict the creep behaviour of the complicated alloys that dominate the engineering field to-day. We do not really understand the mechanism of such processes as recrystallisation under strain nor that by which transient flow is effected. I think, however, that we have reached a stage at which we can set out what are the fundamental problems and to understand the nature of a problem is always an important step towards its solution.

When I was young Caruso was wont to raise his magnificent voice to remind his audience that

La donna è mobile

My voice is harsh, but my theme, if less familiar, is equally true, namely, that, given suitable conditions,

Metalli son mobili

and I think that we shall find the laws that govern this mobility before we understand the other theme.

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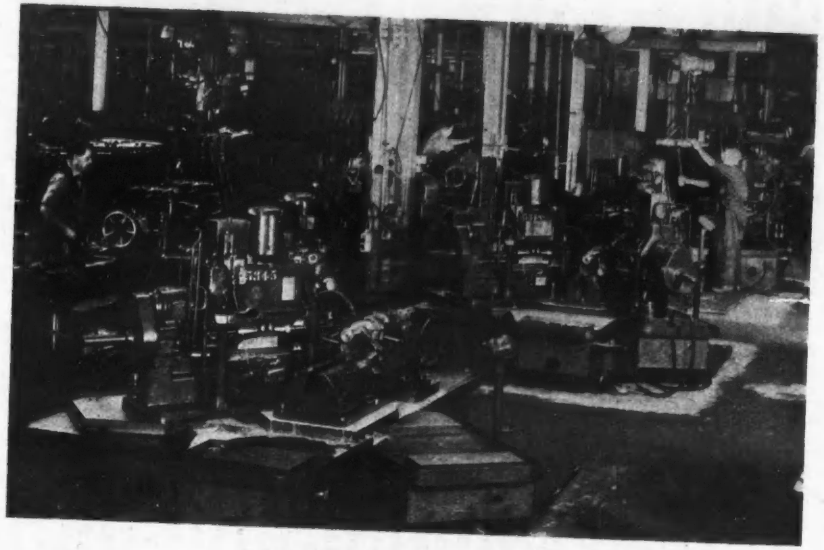
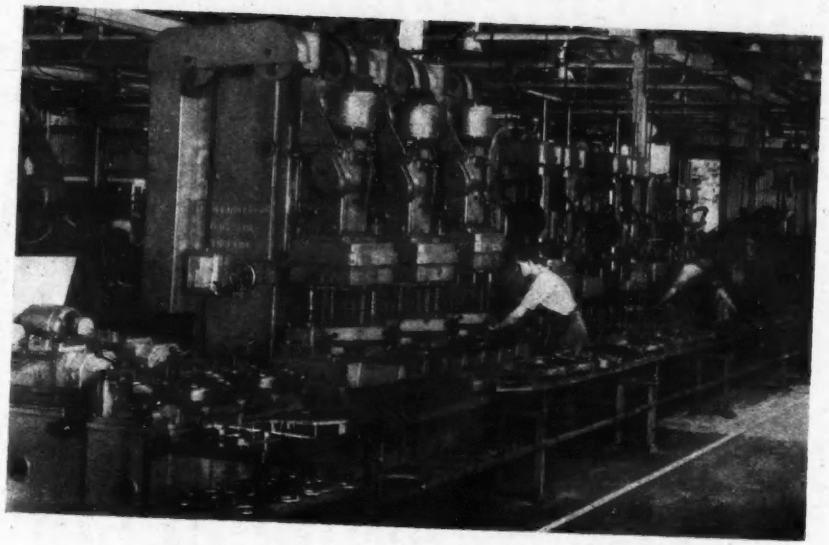
‖ See E. Orowan, "The Creep of Metals," West of Scotland Iron and Steel Institute, 1947, where full references are given.

WORKS OF R. A. LISTER AND COMPANY LTD., DURSLEY

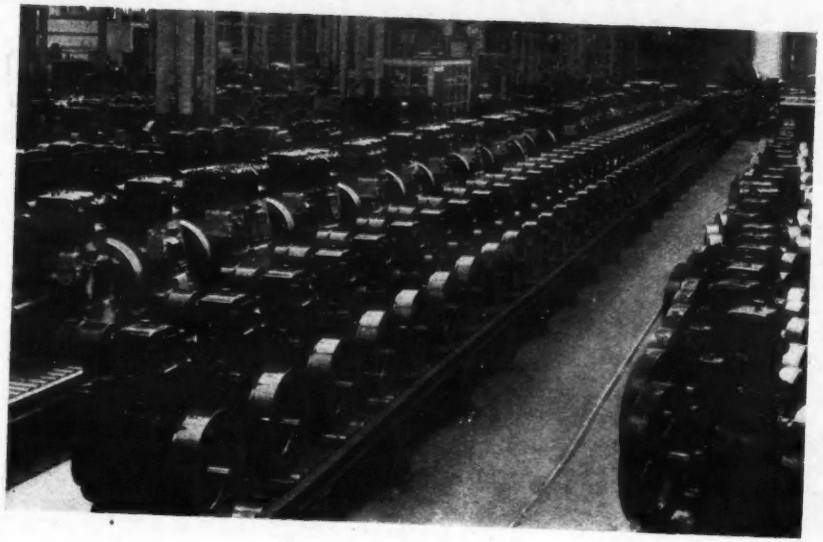
"MAXIMATIC" MULTI-TOOL LATHES



DEEP-HOLE DRILLING MACHINES



GEARCASE BORING, DRILLING AND TAPPING MACHINES



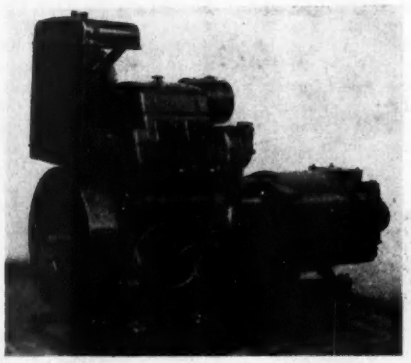
ENGINES AWAITING TEST

The "Freedom" Diesel Engine

During the post-war years R. A. Lister and Co., Ltd., has proceeded with the development of a new range of small diesel engines, the largest being a six-cylinder unit developing 54 b.h.p. at 1800 r.p.m. Exhaustive trials have established the ability of the engine to give a good performance under all climatic conditions, and the company has gone forward with its plans to mass produce the new engine, which has been named "Freedom." For this purpose the works at Dursley have been reorganised and numbers of special-purpose machines have been installed.

FOR some considerable time R. A. Lister and Co., Ltd., of Dursley, in Gloucestershire, has been engaged in developing a new range of moderately powered high-speed diesel engines, which are to be known as the "Freedom" range. This new product of the company has been designed for use as a prime mover for a wide range of agricultural machinery, road-making and mining equipment, the generation of electrical power, and numerous industrial applications.

Every endeavour has been made, from the blue print stage and onwards, to overcome many of the drawbacks often associated with high-speed diesel engines, while details, well proved over the years, have been incorporated in the design. The engines, which are totally enclosed, have been built to give reliable service under all climatic conditions, and to this end all parts have been designed with an adequate margin of strength. This robustness has been achieved without any sacrifice of weight; in fact, the power/weight ratio has been approximately doubled while about 50 per cent increase in speed has been effected with piston speeds only slightly higher than that of some of the company's present range of production. Accessibility to all working parts is assured by reason of easily removable covers and the long and exhaustive tests, to which the engine has been subjected, have



"F.R.2" 10KVA ALTERNATOR SET

indicated that the overall reduction in weight and the increase in speed have not affected the durability of the engine.

The engines, which satisfy Lloyd's requirements, are all cold starting and are produced as single, twin, three, four and six cylinder units, each cylinder developing 8 h.p. at 1500 r.p.m. and, with the exception of the single-cylinder, 9 h.p. at 1800 r.p.m., on a twelve-hour rating, and are suitable for coupling to alternators of 50 c s and 60 c/s. In conformity with the British Standards Specifications, the engine will develop a 10 per cent overload for one hour and the usual deductions will obtain for altitude, temperature and humidity, and continuous rating. The single, twin and three-cylinder engines can be fitted with power take-offs, such as clutches and 2 : 1 reduction gears, and built-in clutches are available for the four and six-cylinder models.

In anticipation of a large demand for the engines from abroad and to ensure the availability of technical services, the personnel of the company's overseas organisation have visited the works during the last year to receive instruction on the engine and instruction schools are to be established at many centres throughout the world.

At the invitation of the company we were able to visit the works at Dursley to inspect the reorganised production lines and to follow the sequence of operations from the foundry to the assembly line and test bay. In the accompanying photograph we illustrate a "Freedom" engine "FR.2" driving a 10kVA alternator.

Materials and Construction

The engines have a cylinder bore and stroke of 3¾in by 4½in to give a piston speed of 1350ft per minute at 1800 r.p.m.

The crankcase is made of cast iron and fitted with easily detachable inspection doors, which give ready access to the connecting-rods, while a detachable sump allows for easy accessibility to the crankshaft bearings. Centrifugally cast wet liners are supplied and are chrome hardened by the "Listard" process, which gives a wear-resisting surface and so, by maintaining combustion pressure, helps towards easy starting. Two rings maintain a water-tight seal and the liner which is secured at the top is free to expand downwards.

Low expansion aluminium alloy pistons with flat crowns are provided and are grooved to take three compression rings and one oil scraper ring above the gudgeon pin and a second scraper ring below the pin. The pistons are oval turned, and have a close-fitting skirt, which gives controlled oil consumption and materially helps to attain smooth running. Circlips retain the fully floating gudgeon pin and the connecting-rod, which is a carbon steel forging, has a phosphor-bronze bush at the small end and a copper-lead big end bearing. The crankshaft is built to Lloyd's specification and is produced from a 60/65-ton manganese-molybdenum steel forging, which is supplied in the heat-treated condition. All the bearing surfaces are accurately ground and the crank journals are 3in in diameter; the journals have hardened surfaces and run in white metal steel-backed bearings having a precision finish so that no special fitting is required.

The cast iron cylinder head incorporates the Lister dual combustion chamber, which, by the operation of a single lever gives an increased compression to ensure easier starting. The device raises the compression ratio of the engine, which is 20 to 1 when running normally, to 24 to 1. By shutting off the second combustion chamber during starting a clean exhaust is ensured and the complete combustion in the cylinder is a safeguard to the injector nozzles, piston rings and valves. Overhead valves are carried in the cylinder head, the inlet being of "Silchrome" and the exhaust of KE steel, and they are actuated by rocker arms through push rods having mushroom-shaped tappets from a camshaft which is of generous dimensions and is well supported, there being a bearing at each cylinder in addition to the locating bearing. An individual rocker assembly has been adopted for each valve, and this has resulted in a compact arrangement of the cylinder head and in simplifying the correct positioning of valves and injectors. Decompression is by a single lever, located outside the engine, which operates on the exhaust valve of each cylinder by means of a cam action. A rotary metering device embodied in the end of the camshaft delivers lubricating oil under pressure to the valve rockers.

Close speed control of the engine is provided by a centrifugal governor, which maintains a "settled" variation within 2 per cent, while overloading is limited to 10 per cent by an automatic release. The governor linkage with the fuel pumps, which are fitted individually at each cylinder, is totally enclosed.

All the auxiliary components are driven from the chain of helical gears which are grouped at one end of the engine and cut to very fine limits to ensure the minimum of backlash and silent running. The gears are enclosed in a cast iron gearcase.

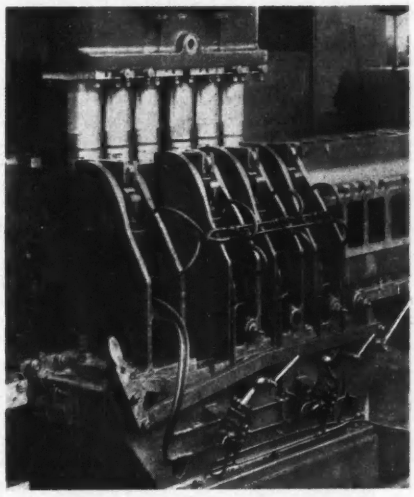
Lubrication oil is circulated by a gear pump which draws oil from the deep sump through a large-capacity oil strainer and passes it through an oil gallery to all working parts. The pump is mounted externally above the oil level and special provision is made to ensure instantaneous priming. The fuel oil is cleaned in a filter which consists of a large-capacity element spirally wound in a special container to provide the maximum effective filtration area and the complete unit is housed in a settling chamber, which is an integral part of the crankcase, so that unnecessary piping is eliminated.

The air supply is drawn in through a large-capacity cleaner of the oil bath pattern, baffles deposit any foreign matter into a detachable oil-filled trough and a swirling motion is imparted to the air by centrifugal action. Embodied in the cleaner is a Lister patent air silencer, which considerably reduces air intake noise. Cooling is by radiator or tank and the system is of directional design, the water being circulated by a circulating pump of impeller pattern, which has a minimum output of 250 gallons per hour per cylinder. The pump driving shaft is mounted in ball bearings and is carried through the pump to provide dynamo and tachometer drives and carbon seals are fitted to prevent leakage.

Although designed for hand starting, provision has been made for 12V electric starting equipment, the starter motor engaging with a replaceable gear ring shrunk on to the flywheel rim.

Production

Since the war the company has gone forward with the development of the engine and has made comprehensive arrangements for its pro-



"F.R.6" LINER BORES IN OPERATION

duction at Dursley. To this end the machine shops have been re-equipped with special-purpose machinery so as to be able to produce 1000 "Freedom" engines per week.

The castings are produced in a fully mechanised foundry, which was completed in 1939 and has 1½ miles of conveyor track. Raw materials in the charging bay are serviced by a magnet crane and the four cupolas of 70 tons per day total capacity are mechanically charged under laboratory control. The cores for the crankcase casting are blown on Osborn machines and carried by overhead conveyor to continuous baking stoves and then coated with a liquid to withstand high metal temperatures. Pneumatic machines working in pairs produce the finished moulds, which are carried to the casting section on a double loop track moving at 12ft per minute. After the pouring operation the moulds pass through a fume extraction chamber to the vibratory knockout screens, the moulds being returned to the moulding section by

pendulum conveyor and the hot castings are transported in buckets on an overhead conveyor direct to the fettling shop, there being no stacking.

The sand is recovered and reconditioned; it passes through rotary screens, a barrel mill, a paddle wheel aerator, and then returns via a push plate conveyor to the moulding machines. The castings are passed through a wheelabrator plant on rotating pendulum hooks and cleaned by small shot projected at them by three impeller wheels rotating at 3000 r.p.m., and set at different angles. After inspection the castings are gauged and machining location spots are ground.

The various operations on the crankcase are carried out on a planned sequence by lines of special machines which include Cincinnati milling machines, Archdale multi-spindle drilling, boring and tapping machines, and an Asquith boring machine. All six external faces are milled on duplex millers having a feed of 10in per minute and using carbide-tipped 20in diameter cutters rotating at 48 r.p.m., The bearing channel is cut on a horizontal and vertical spindle machine, staggered tooth side and face cutters removing most of the metal while the bottom and sides are finished by a standard face mill and the bearings then milled to width.

All subsequent operations are located from two dowel holes drilled and reamed in the pump face. Now follows the rough bore, semi-finish bore and finish bore of the main crankshaft bearings and camshaft tunnel with intermediate operations involving the drilling, tapping and counterboring of various holes in the side and end faces, and in the main bearings, the drilling and reaming of tappet guide holes and the boring of the lands for the cylinder liner and of the liner housings, which we illustrate. Standard radial drilling machines, at the end of the line, carry out deep hole drilling and tapping. An extensive use is made of pneumatically operated jigs throughout the operations and the crankcase casting passes to the various machines on a roller conveyor arranged at bed height. Before machining, the crankcase is subjected to a pressure of 100 lb. per square inch in a pneumatically operated hydraulic testing fixture.

After removing scale and flash the crankshaft forgings are centred on a double-ended machine and a patch turned and ground for location. The locating and centre bearings and drive coupling taper are rough turned in a "Maximatic" multi-tool lathe, as seen in our photograph, and the opposite end of the shaft turned in a second machine. For setting in the crank pin forming machines, which are Drummond "Maximatics" with front and rear-forming slides, two patches are ground in the journals and a location spot milled on one web. The journals are now finish turned in a similar set of machines. The crank webs are milled to take the balance weight and the stud holes drilled and tapped.

In our photograph we show the special-purpose Archdale deep hole drilling machines, which have a hydraulic feed and an automatic relief set at 100 lb, which are used for drilling the long axial and angular oil holes. After grinding the location and intermediate bearings the pinion diameter and long end taper are profiled in a John Lund "Prectmax" grinding machine having a wheel of three diameters and 8¼in wide. A Landis crank pin grinding machine with a hydraulically operated fixture grinds the pins and the final operations on the shaft includes the cutting of keyways and the boring of the end for particular requirements.

An oil hole is drilled and reamed part way through the forged camshaft and this is used for radial location during subsequent operations. By means of turning and three grinding operations on the cams allied with checks for straightness, the case-hardened surface of the cams is of even depth and hardness. "Maximinor" multi-tool lathes are used for turning the camshaft diameters, while the cam profiles are turned on a Scrivener machine, which can turn eighteen cams simultaneously. The cams are rough ground in the soft state, in two passes and then carburised and hardened, after which they are semi-finish and finish ground in a fully automatic Landis grinding machine.

The cast iron gearcase, in common with the other cast iron parts of the engine, is painted with a sealing paint before machining, and a battery of Pollard machines, seen in our photograph, completes all the necessary boring, drilling and tapping operations after the preliminary grinding and milling has been finished. All the flywheels pass to a Bullard "Man-au-trol" automatic vertical turret lathe, which machines all the faces on one side and the taper bore, the other face being completed on a manually operated machine. The wheels are statically balanced and a limit weight acts as a check on the homogeneous structure of the iron.

The engines are erected on a roller conveyor fed by sub-assemblies. The feet are added to the case, pistons put into the liners, the fuel pump brackets are fitted, followed by the tappet blocks, main bearings, crankshaft, and the big end and main bearing caps. These items are succeeded by the oil pump, end cover, camshaft, flywheel, camshaft gear wheel and pump drive, and then the final fittings are mounted, including the gearcase cover, driving flange, governor mechanism, water pump, cylinder head, rocker box, and air cleaner. After painting the completed unit is passed through a gas-heated dryer to be touch dry in one hour.

The engines, which can be seen in our illustration awaiting test, now are forwarded to the test beds, of which there are sixty-five in operation, with several more nearly ready for service, where they undergo a light-load test for two hours, followed by four hours on full load, including a short period on 10 per cent overload. The fuel consumption is carefully checked, the temperatures of the exhaust and circulating water taken, and the oil pressures recorded, while the horsepower is measured mechanically by a spring balance, which records the movement of the stator of an electrical dynamometer. The exhaust from the engines is led away in under the floor ducts to a common silencer.

Quantity Production of Glass Bulbs

A factory with a daily productive capacity of 1,500,000 glass bulbs for the lamp and valve manufacturing industries has been established at Harworth, Notts. It is operated by Glass Bulbs, Ltd., a new company formed jointly by the British Thomson-Houston Company, Ltd., and the General Electric Company, Ltd. The scale of the output from this factory depends on advanced methods of handling raw materials to feed a continuous production process based on two "ribbon" type bulb making machines which originated in the U.S.A.

LAST week we took part in a Press visit to the Glass Bulbs, Ltd., factory at Harworth, Notts, where we saw a plant that has been designed for the production of lamp and valve bulbs on a scale that is beyond anything attempted outside the U.S.A. The output capacity of 1,500,000 glass bulbs a day is enough for the needs of "Mazda" and "Osram" general service lamps and of other lamp manufacturers in the United Kingdom, with a substantial surplus for exports to Europe and the British Commonwealth. To obtain this output the complete plant is equipped and arranged for providing a continuous flow of molten glass to the bulb forming "ribbon" machines which are up-to-date versions of the American Corning machines.

FIG. 1—WEIGHING MACHINES IN MIXING TOWER

The site of the Harworth factory is well provided with the facilities needed for a plant such as this. There is no shortage of female labour from the nearby villages and the adjoining Harworth Colliery is a source of supply for the coke oven gas required for firing the glass furnaces. All the raw materials are readily accessible: soda ash from Northwich, limestone from Buxton, sand from King's Lynn, and dolomite from a local source near Doncaster. Private sidings enable the raw materials to be delivered by rail to the works, where they are discharged directly into a storage and mixing tower at one end of the factory, as illustrated opposite (Fig. 2). The tower has facilities for storing, weighing, batching and mixing the raw materials, while the rest of the production process—the furnace, "ribbon" machines, annealing lehrs, inspection and packaging—and the ancillary functions of the workshop, stores, chemical laboratory, and main offices are housed in the main factory building, which is 700ft long by 80ft wide.

The mixing tower is a reinforced concrete structure, octagonal in plan and 100ft. high. It embodies seven silos extending over the whole height of the tower. Each silo has a capacity of 1500 tons and provides storage space for one of the main materials—soda ash, dolomites, limestone, sand, felspar, and cullet or suplus glass. The soda ash, dolomites and limestone

are raised to the top of their silos by suction. The lower end of each suction pipe consists of an annular nozzle through which air is sucked, entraining the material and drawing it up the pipe into a primary receiver at the top of the tower. In the receiver the air velocity is reduced and the entrained material falls to the bottom, whence it is discharged under gravity on to a sloping shelf which forms the primary storage in the silo. Before being discharged to atmosphere the air is drawn into a secondary receiver, which extracts the finer particles, discharges them into the silo and exhausts dust-free air. Surplus material spills over the edge of the shelf and falls to the base of the silo, whence it can be recovered, by suction, as required. Our illustration of the tower shows three suction lines unloading material from railway wagons.

Sand is conveyed to the silo under pneumatic pressure instead of by suction. The sand is first sieved mechanically, the accepted material being fed by gravity through a pipe into the throat of a Venturi tube, which forms part of a closed circuit compressed air delivery system discharging into the top of the appropriate silo. The cullet is delivered to its silo by a mechanical bucket conveyor inside the tower. Besides the main constituents the glass contains

FIG. 2—MIXING TOWER WITH RAW MATERIALS SUCTION CONVEYOR

small amounts of various chemicals, such as sodium sulphate, ammonium sulphate, nitre and arsenic, which are stored conventionally in a room at the top of the mixing tower.

The main raw materials are reclaimed mechanically from the storage shelves at the top of the various silos and then pass down chutes to the automatic weighing machines two floors below (Fig. 1), whence the correct amount of each material is discharged into a rotary mixing drum. On the floor immediately below the outflow at the top of the tower are the remote control panels, whereby the whole operation of weighing and mixing can be supervised by two men with the help of sets of coloured indicator lamps on the panels to show the progress of operations. One set of lamps shows the conditions in the silos and indicates when replenishment is required. Another set of indicators shows the start and finish of the weighing of each constituent, the discharge into the mixing drum and the completion of the mixing process. The sequence of operations briefly is as follows. When the weighing of all the materials, except the cullet, has been completed they are mixed under the control of an adjustable timer for thirty seconds. Half the total amount of cullet is then discharged into the drum and mixing continues for a further one and a half minutes. The rest of the charge of cullet is then added and mixing is continued for another half minute.

From the mixing drum the blended materials are automatically discharged into canisters,

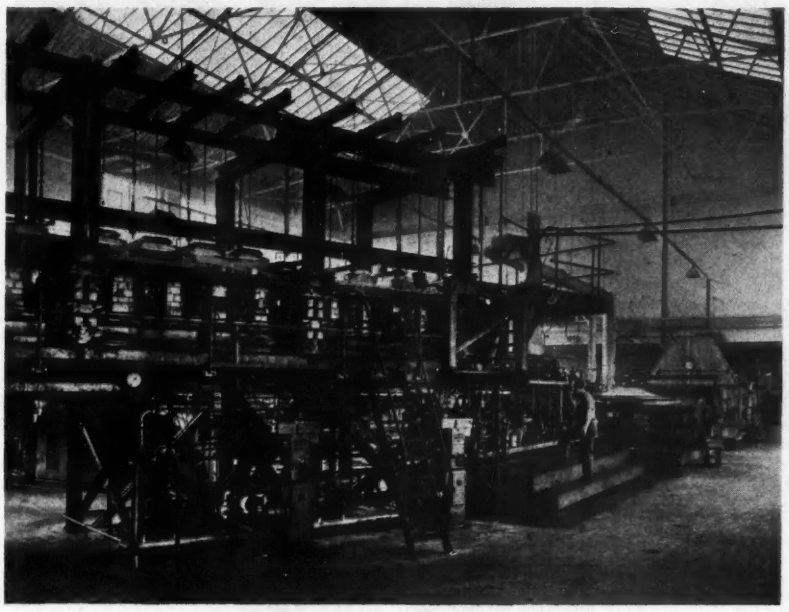


FIG. 3—FOREHEARTH AND "RIBBON" MACHINE

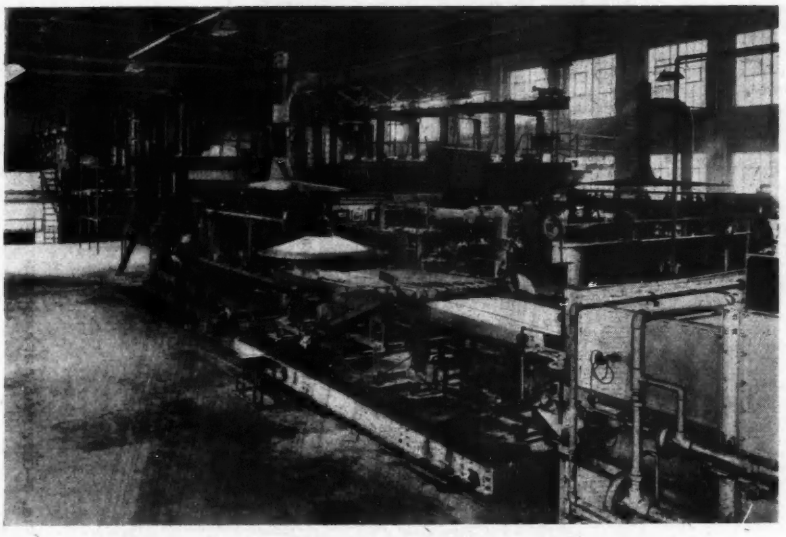


FIG. 4—FURNACE, "RIBBON" MACHINE AND ANNEALING OVEN

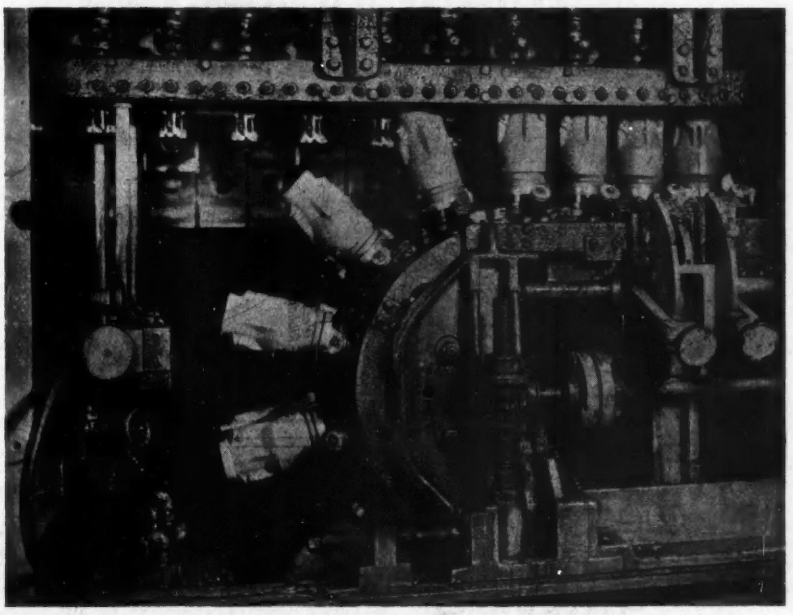


FIG. 5—BULB BLANKS ENTERING SPLIT MOULDS

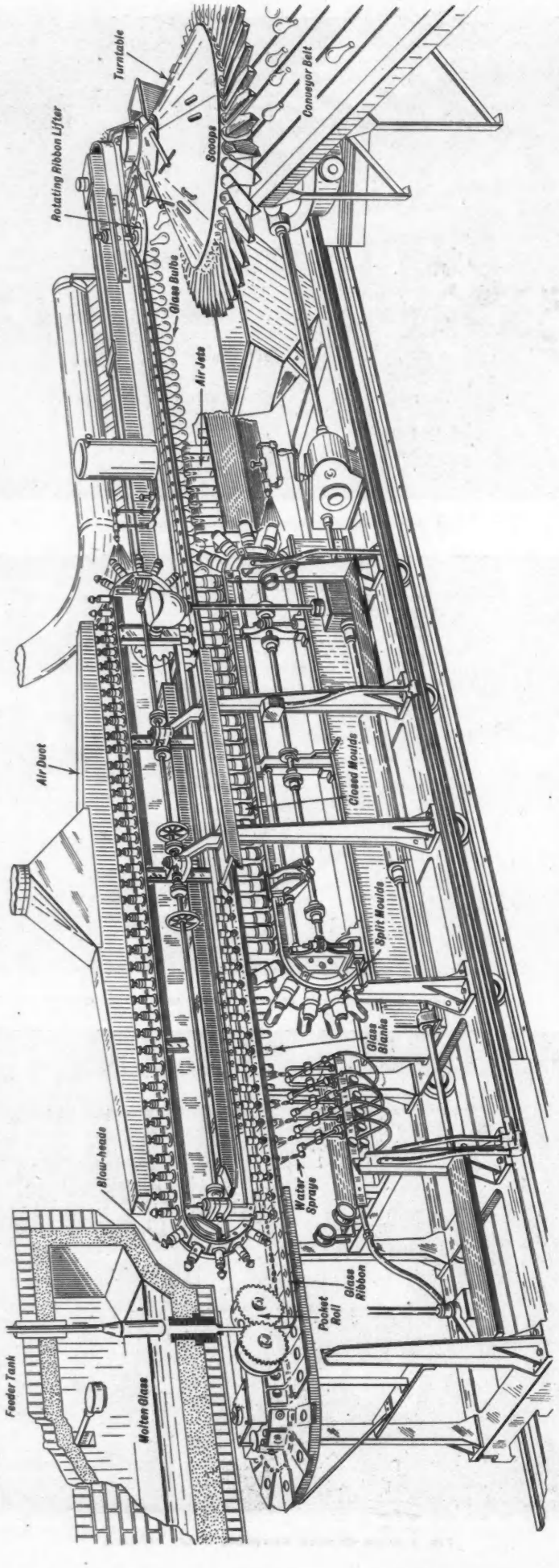


FIG. 6—GENERAL ARRANGEMENT OF "RIBBON" MACHINE

which are mechanically conveyed on a roller runway to the hopper, from which the furnace is fed. The hopper discharges into electrically operated, mobile screw feeders, which force the charge or batch into the mouth of the glass furnace.

This equipment is a continuous tank, cross-fired, regenerative furnace, capable of producing 150 tons of glass daily. It is fired with coke oven gas and the regenerative arrangement effects useful economy in fuel by ensuring that the incoming air is preheated before entering the furnace.

Temperatures are suitably graded through the melting and refining ends, the glass finally passing through the forehearths, (Fig. 3) which are automatic and bring the glass to the temperature required for feeding to the ribbon machines. Pressure in the furnace is maintained automatically at slightly above atmosphere. Remote recording and metering instruments are grouped on panels in the machine room. The glass produced in this furnace has, roughly, the following composition: silica, 72 per cent; soda, 18 per cent; lime, 6 per cent; and magnesia, 3 per cent.

On leaving the forehearth a controlled stream of molten glass flows down between two rotating water-cooled rollers at one end of the ribbon machine (Figs. 4, 5, 6). One roller has a plain surface, the other contains circular depressions (Fig. 6), so that the glass issues from between them as a continuous ribbon bearing a series of equally spaced bosses of the right thickness to provide enough glass for each bulb that is to be produced. On leaving the rollers the ribbon is carried on a continuous belt of articulated orifice plates, each of which is pierced with a circular hole that comes accurately into position beneath the "hump." Moving forward on the orifice plates, the ribbon now meets a continuous chain of blow-heads, which descend on to it from above, each blow head pressing into the centre of a "hump" directly over a hole in each orifice plate.

A puff of compressed air issuing from the blow-head causes the "hump" to be extruded downwards through the hole in the orifice plate, the function of which is to determine the diameter of the flare at the top of the neck of the finished bulb. These rudimentary bulbs, or glass blanks, hanging below the rapidly moving ribbon, increase in depth until they meet the split moulds which rise from below on a continuous belt and close round them from both sides (Fig. 5). At this point the ribbon, blow-heads and moulds are all moving forward together at the same speed. The moulds now begin to rotate through the medium of stationary racks engaging with a pinion in the base of each mould. Meanwhile the air pressure from the blow-heads increases so that the glass blanks are moulded to their final shape. Then the moulds stop rotating, open, leave the bulbs, and return on their belt under the machine. Similarly the blow-heads break contact with the glass ribbon and return along the machine on the upper side of their chain. The orifice plates, carrying the ribbon with the blown bulbs hanging beneath it, continue to travel forwards while jets of cooling air play upon the completed bulbs. On reaching the rotating ribbon lifter the bulbs are successively tapped off by a synchronised hammer and fall into the scoops of a rotary turntable which tip them on to a moving belt for annealing in a gas-fired lehr. The glass ribbon passes down to the floor below, where it is water cooled and subsequently broken up for re-use as cullet, while the orifice plates return horizontally behind the machine.

To ensure a polished surface on the glass bulbs each mould is lined with a thin coating (not more than 0·004in) of powdered cork baked in linseed oil. The heat of the glass transforms the cork into fine carbon, which readily absorbs water from the cooling sprays that play on the moulds as they pass back under the machine. On coming into contact with the hot glass, the water is vaporised, so that the bulbs are formed in a cushion of steam, which leaves them with a polished surface finish.

The two ribbon machines are of different sizes; the larger one has a pitch of 3·9in

between the orifice plates, the smaller a pitch of 3in. There are in all seven different sizes of orifice plate, and rollers of two different depths of pocket, $^{7}/_{32}$in and $^{9}/_{32}$in respectively. This range adequately covers all the sizes of bulbs and valve envelopes produced.

Each ribbon machine is driven by a 10 h.p. compound-wound d.c. motor supplied from a three-phase full-wave rectifier and operated under electronic control, designed to maintain constant speed at any setting within $\pm\frac{1}{2}$ per cent for a 10 per cent variation in voltage. This form of control enables the motor speed to be varied from a crawl to 1750 r.p.m.

The larger machine, with moulds at 3·9in centres, produces from 350 to 500 bulbs a minute in the 70mm, 75mm and 80mm sizes for 75W, 100W and 150W general lighting service lamps. Operating on a continuous twenty-four-hour schedule, this machine gives a daily output of approximately 500,000 bulbs. The smaller machine, in which the mould centres are at a 3in pitch, will produce the whole range of valve bulbs up to 44·5mm diameter, including all the miniature types, and lamp bulbs from the 25mm stop and tail light size up to and including the 65mm bulb for the 60W general service lamp. The output of this machine, which runs continuously throughout the twenty-four hours, is approximately 1,000,000 bulbs daily, or more than ten per second.

After annealing, the bulbs are air cooled while proceeding on a conveyor belt to the packers. Continuous inspection is carried out on a quality control basis, and at the control point five bulbs are picked off the belt every twelve minutes for examination and dimensional checks.

The packing of bulbs into cartons, labelling and sealing down take place on two floors of the main factory building, whence the cartons pass on conveyors to the finished bulb store. This building is 700ft long by 110ft wide; a railway siding gives access over the full length of the store on one side. On the opposite side are the road loading docks. All loading into road and rail vehicles takes place under cover. Pallets and fork lift trucks expedite the movement of cartons within the store, which can accommodate approximately 40,000,000 bulbs.

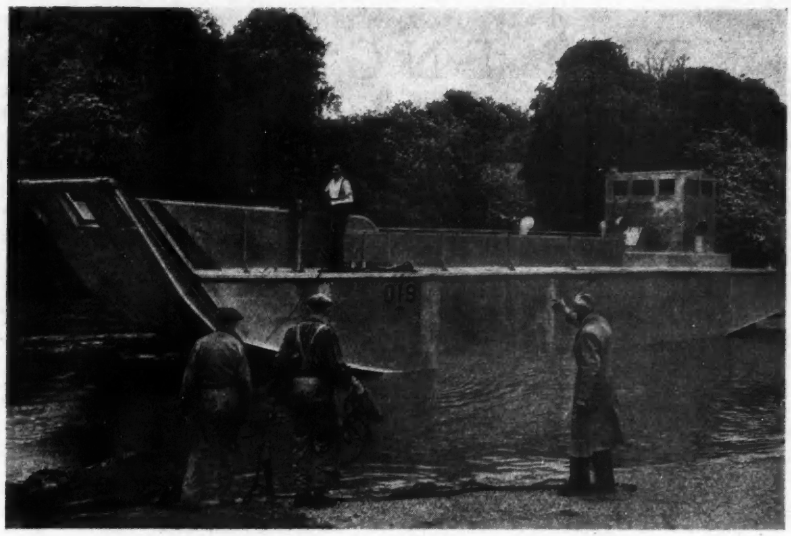
Electric power for the works is supplied from a transformer substation on the factory site. All the equipment is operated by a.c. motors with the exception of the ribbon machines, as stated. To ensure continuity of supply in the event of a power cut, emergency diesel alternator sets have been installed; oil storage tanks have also been provided to enable the furnace to be oil fired should the normal supply of gas fail.

Aluminium Alloy Cargo Lighter

Two prototype ramped cargo lighters have recently been built by Watercraft, Ltd., to the designs of the Fairmile Construction Company, Ltd., for the Royal Pakistan Navy, and our photograph shows one of the lighters immediately after being launched. The building material chosen was aluminium alloy to enable the craft to carry the maximum load on minimum draught, and comparison with a war-time built steel landing craft of similar dimensions reveals the savings effected by using light metal.

The following are the principal dimensions:—Length over ramp, 60ft; length on deck, 56ft; beam, 16ft; and depth, 6ft; all of which closely approximate to those of the "LCM VII" landing craft. With a load of 30 tons on board the displacement is 43 tons and the draught 3ft, and these figures compare with 58 tons and 3ft 6in draught for the steel vessel, showing that the loaded aluminium craft weighs under 70 per cent of the steel craft and has 6in less draught. The light displacement of the craft is 10 tons and the draught 1ft 1in.

The British Aluminium Company, Ltd., has supplied the constructional material, which is to B.S. 1477, NP5/6 alloy for the plates and B.S. 1472, HE 10, W.P. for the sections, while the rivets are to specification NR 6. The plating for the shell, floors, deck, hold sides, and bulkheads is $\frac{1}{16}$in thick and the framing and beams, which are spaced 18in apart, consist of 2in by 2in by $\frac{1}{4}$in ordinary angles. A double reduction winch of $\frac{1}{2}$ ton capacity operates the ramp, which is of $\frac{1}{4}$in thick plate, stiffened with 2in by 2in by $\frac{1}{4}$in angles and sheathed with hardwood. Two six-cylinder petrol engines, each developing 95 b.h.p. at 2600 r.p.m., and fitted with a 1·95 to 1 reduction gear, drive three-bladed aluminium alloy propellers of 26in diameter by 13in pitch to give the lighter a speed of 7 to 9 knots. The propellers are mounted on Monel metal shafts running in cutless bearings in the galvanised steel shaft brackets and Tufnol bearings in the light alloy shaft tubes.



ROYAL PAKISTAN NAVY RAMPED CARGO LIGHTER

An Improved Television Camera Cable System

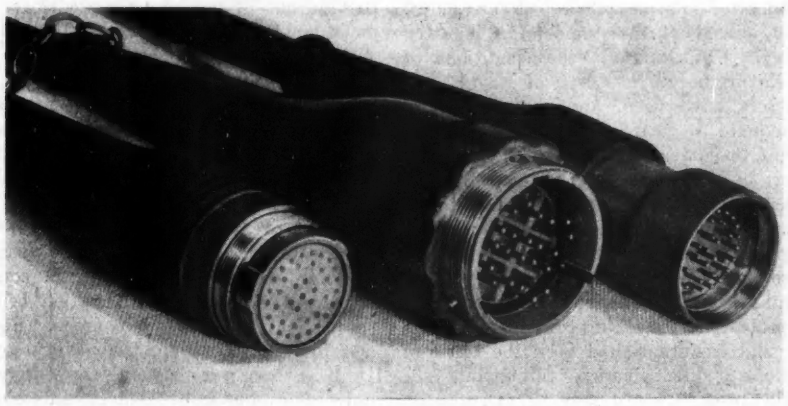
IMPROVEMENTS have been effected in the "Polypole" television camera cable system, introduced in 1949 by British Insulated Callender's Cables, Ltd., 21, Bloomsbury Street, London, W.C.1. The "Polypole" system provides high performance, single-strand cable in unit lengths, each of which is fitted with integrally moulded-on couplers designed to withstand the working conditions to be expected in service. The couplers are moulded integrally with the cable in the factory and the connections can be permanently made such that the mechanical strength of the termination is as good as that of the remainder of the cable. Compared with its predecessor, the new equipment, which is known as the "Polyphase III" coupler, is smaller and lighter and provides for up to thirty-six circuits, as illustrated herewith.

The cables are of small dimensions, due partly to the use of single-strand conductors and to the high accuracy extrusion processes evolved for applying the polythene dielectric. The overall diameter of the latest thirty-six circuit cable, for example, is only 0·82in. This cable consists of a centre of three screened circuits, each of which may be coaxial or balanced twin, and three triplets of insulated conductors. The outer layer contains twenty-one single insulated conductors.

The cables are screened overall and sheathed with P.V.C. or tough rubber; they are light in use, easily handled and kinking is eliminated; they can be bent in a small radius without injury.

Unit lengths of cable can be built up as required, using the couplers, which consist of male and female connectors. The thirty-six contacts are arranged so that the circuit passes through the coupling in the same geometrical disposition as in the cable. Each coaxial or balanced twin unit has two contacts, the screen in the former case being isolated from adjacent coaxial screens and from other screens in the cable.

Although the couplers are integrally moulded to the ends of the cable, the aluminium bronze housings can readily be replaced if damaged. Even when the casing is removed the moulded interior is waterproof.



"POLYPOLE III" COUPLER WITH ITS PREDECESSOR

THE ENGINEER

Vol. CXCIII MAY 23, 1952 No. 5026

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THE ROYAL CORPS OF NAVAL CONSTRUCTORS

RECENT developments in the fields of marine engineering and naval armaments indicate the probability of far-reaching changes in warship design in the coming years. The new fast anti-submarine frigate now being build is replacing the destroyer and with the coming into use of nuclear energy for the propulsion of ships and the probable replacement of conventional naval artillery by the guided rocket and other air missiles, we may eventually see a return to the capital ship—not the 35,000-ton battleship as we know her to-day, but a smaller, faster and more expendable vessel. It is thus more than ever important that, during this period of revolutionary change in design, the men who are responsible for designing ships and co-ordinating their engineering and electrical services and their armament should have a very high standard of technical skill and administrative ability. And if first-rate men are to be obtained it is essential that the careers offered to them should be superior to, or in any event not inferior to, those offered in the engineering industry to-day. Unfortunately, the conditions of service in the Royal Corps of Naval Constructors have been, and are still, quite inadequate to attract the right kind of recruit in sufficient numbers. Following a report by a committee set up after the war under the chairmanship of Sir Tom Eastham, it was decided that the pay scales of the Corps should be brought up to the level of those of Civil Service scientists, and some six months ago an increase of pay was approved for probationary assistant constructors whose pay and conditions had been the cause of particular dissatisfaction throughout the whole Corps.

In the debate on the 1952–1953 Navy Estimates in the Lords, Viscount Caldecote, who himself served as a naval constructor, pointed out that constructors required a much longer training and had fewer jobs and opportunities open to them than Civil Service scientists, and that the prospects for the Corps were considerably worse than those in the administrative grades of the Civil Service, which a man joins as an assistant principal. On entering the Corps the twenty-two-year-old recruit from a university receives only £330 compared with the £500 he might expect to receive at once if he went into industry. After four years' training, the naval constructor receives £550 on a scale rising to £800, and goes on to the £950–£1375 scale after a further ten years' service. Ever since the Corps was founded on a civilian basis in 1883 the Admiralty has had difficulty in preventing the best men leaving owing to the higher pay and better prospects offered in private shipbuilding yards. The present strength of the Corps is 175 with twenty temporaries, compared with a strength of 300 fully qualified constructors recommended by the Eastham Committee. Indeed, the fact that entries are permitted on a temporary basis at all indicates that regular recruits are not joining in adequate numbers. Since 1949 there have been only twelve recruits and there have been twenty-one resignations. It was hoped that the universities would provide one of the best sources of recruitment, and for a short time from 1936 onwards—the year when the possibility of war was once again under consideration—the universities and engineering establishments did their share in making good deficiencies. During that period twenty-five promising recruits, with high university and architectural qualifications joined the Corps, but fourteen of them—more than half—have since resigned. These men were more or less fully trained—at a cost to the country of some £1500 each—and they left because they found conditions impossible. Entries are, in fact, drying up from every source. In 1951 there was only one entry from the universities, one from the dockyards and one from the private shipyards. There is, indeed, little hope of a satisfactory solution as long as the Corps continues to be treated as a branch of the technical Civil Service, for the Government cannot compete with industry in the salaries offered to men of great technical ability. Viscount Cunningham, Lord Chatfield, and other experienced naval officers who have given their minds to the problem are convinced that the obvious and only satisfactory solution—a solution which has been strongly recommended in this journal—is to make the Royal Corps of Naval Constructors an integral part of the naval service, as is the case in the United States Navy.

Naval Constructors do not at present spend much of their time at sea—one or two were employed on the staffs of the Commanders-in-Chief of our fleets during the war, and they also embark in ships for seagoing trials on completion of building or after a major refit—but as naval officers they would be expected to go to sea more frequently during their career. And, if this meant increasing the strength of the Corps in accordance with the recommendation of the Eastham Committee, it would be an immense advantage that they should have practical experience, under seagoing conditions, of the ships they design. There would certainly be no lack of recruits, for the Navy and a life at sea have always proved a great attraction for the British people, and there never has been, nor is there likely to be a dearth of first-class brains in any branch—executive or technical—of the Royal Navy. In our view it is also essential to increase the number of posts in the higher ranks, not only for constructors, but for all officers of the technical branches of the Royal Navy. There should be a combined Technical Service to include all technical officers—Engineering Branch (Marine, Weapon and Air), Electrical Branch and Constructor Branch. Senior officers of this Combined Service might well be interchangeable as candidates for command of Technical Training Establishments, for Admirals Superintendent of Dockyards and also for a seat on the Board of Admiralty.

FIRES IN TRAINS

THREE serious fires have occurred in railway passenger trains recently, at Penmanshiel in 1949, at Beattock in 1950 and at Huntingdon in 1951. There was, too, a similar fire at Westborough in 1941. The Huntingdon fire broke out on the "West Riding" express from King's Cross to Leeds on July 14, 1951, near Huntingdon, and is the subject of a report by Col. R. J. Walker, inspecting officer to the Ministry of Transport, published last week. It occurred in the second coach, one of a twin open third brake set having a common bogie between the coaches, and the four leading coaches of the train were completely burnt out. Fortunately, there was no loss of life—at Beattock five and at Westborough six people were killed—though a number of passengers were injured. In all probability the fire was started by a live coal from the engine lodging in a hole in the floor of the coach, through which an air duct to the toilet was taken. There it smouldered, until smoke within the carriage alarmed the passengers. When the train came to a stand as a consequence of the communication chain being pulled flame came into contact with a leather cloth covering on the inside of the coach and "in a very few seconds the end of the coach was fully ablaze, and the fire was out of control." Col. Walker finds cause for criticism in a number of matters serious enough in them-

selves, yet details in relation to his main points. The actions of the train staff were not satisfactory when the smoke was first seen; two out of six extinguishers brought into play failed to operate, the passengers had difficulty in finding the communication chain. His main purpose, however, is to show the close parallel between this fire and that at Penmanshiel in 1949, through which seven passengers were injured. At both fires the flames spread with great rapidity, owing to the prominence at Penmanshiel of an inflammable cellulose lacquer, and at Huntingdon of an almost equally inflammable nitrocellulose coated cloth brought down on the sides of the coach to floor level. At both, and at Beattock and Westborough, too, passengers experienced great difficulty in escaping from the coaches.

After the Beattock fire a number of recommendations were made to the Railway Executive, which, upon most points, acted energetically and promptly. For instance, coaches containing the offending lacquer were traced and, though there were many thousands of them, the work of putting the matter right was set urgently in hand; and in many detail respects the design of new coaches was modified and changes were made in the structure of existing coaches to make the outbreak of fire less probable and its spread less likely. Three recommendations, however, were refused. They were that there should be some form of organisation among the staff for dealing with fires (which the Executive then considered impracticable, though since the Huntingdon fire it has agreed to the introduction of a rule that will cause a train to be halted if a small fire cannot be quickly extinguished); that there should be additional doors in centre-corridor coaches; and that an extra door should be placed in the corridor of sleeping cars. In the report under discussion Col. Walker reiterates those recommendations, believing the need to implement them to have been reinforced by the experience at Huntingdon. There the twin coaches in which the fire originated had a common bogie. Above the bogie were doors interconnecting the two coaches, but no exit. To get out, passengers had to move towards one end or the other of the twin coach set. But the fire having originated at one end, all the passengers had in the present instance to attempt to get out at the other. In the event only about half of the forty-two passengers in the affected coach got through into its twin; the rest had to break windows and leap down on the line. Undoubtedly additional doors in the sides of each coach would have made more orderly, more rapid, and safer exit possible.

Why, then, does the Executive object to the provision of centre doors as recommended? Certainly cost enters into the matter even though it is not proposed that existing stock should be altered. There also enter other arguments, such, for instance, as the possibility that seating capacity would be lost and that there would be a loss of amenity were centre doors to be inserted. The Executive argues that the degree of risk should be balanced against the cost in one form or another—that is, in amenity, &c., as well as in money—of removing it. It clearly has in mind, too, that when action has been taken, as it is being taken, to make coaches less inflammable, it is neither likely that an incipient fire will go undetected nor that it will be impossible either to extinguish the fire or stop the train before any serious spread of flame occurs. The statistics quoted by Col. Walker of an average of eighty-seven fires in passenger trains reported to the Ministry per year gives as much support to the Executive's view as to his own, for while indicating the not inconsiderable liability of outbreak of fire on trains, it also shows how seldom those fires become serious when no unusually inflammable material is present. The Executive, on the one hand, considers that a need to provide rapid means of exit would only exist if the materials used in coaches were to continue to remain inflammable; and that as a consequence of the exclusion of such materials the chance of rapid spread of flame will become negligible. On the other hand, Col. Walker, seeing the necessity to have furnishings and upholstery in coaches and bedding, &c., in sleepers, rates the chances of a rapid spread of fire as still high despite the precautions the Executive is taking to prevent fires starting in inaccessible places and to prevent spread if a fire does start. Facts have a way of clearing up such disagreements. But in this instance we very sincerely hope that it will be the lack of any further event that will decide the issue.

Obituary

DR. WILLIAM WILSON

We regret to have to record the death of Dr. William Wilson, M.I.E.E., of 111, Grange Road, Birmingham, which occurred in hospital on Friday last, May 16th. Dr. Wilson, who was sixty-nine, was head of the development laboratory at the Witton works of the General Electric Company, Ltd.

William Wilson was born in New Zealand and was educated at Christ's College and Canterbury University College, Christchurch. Subsequently he was, for a period of seven years, a lecturer in electrical engineering at Auckland University College. Dr. Wilson came to England in 1916 and in the following year he joined the staff of the General Electric Company, Ltd. During his long period of service with that company he was primarily responsible for the formation of the development department for switch and control gear, which later on was merged with the development laboratories at Witton.

Dr. Wilson held over sixty patents, most of them relating to switch and protective gear. In addition, he was the author of many well-known textbooks. He was elected to membership of the Institution of Electrical Engineers in 1922, serving as chairman of the South Midland centre in 1927 and of the South Midland radio group in 1944. Dr. Wilson also did valuable work for the electrical engineering industry as chairman of various technical committees set up by the British Standards Institution, the Electrical Research Association, and the British Electrical and Allied Manufacturers' Association. In addition, he was a Fellow of the Institute of Physics and a Member of the American Institute of Electrical Engineers. In recognition of his outstanding contributions to the advancement of electrical science and technology, Dr. Wilson was made an honorary associate of the Birmingham College of Technology in 1949.

Literature

Beton Precontraint. By Y. Guyon. Paris: Editions Eyrolles, 61, Boulevard Saint Germain (V^e). Price 4500 francs.

Monsieur Guyon needs no introduction to the serious student of prestressed concrete in this country. For those to whom his name is not yet familiar the statement in the preface by Monsieur Freyssinet that the majority of Monsieur Guyon's ideas about prestressed concrete coincide with his own, should dispel any doubts whether this book is written by an acknowledged authority on the subject. The book covers very exhaustively (in some 700 pages) the whole subject of prestressed concrete as it is applied to simply supported beams. This, however, does not mean that it contains no information of value to the engineer who is primarily concerned with continuous structures since only 200 pages deal exclusively with the calculations related to simply supported beams. The rest of the book considers, with particular reference to the Freyssinet system, the more fundamental problems which would arise in any prestressed structure and, therefore, fills an important gap in the literature on the subject. A detailed description is given of the various Freyssinet jacks and methods of anchoring the wires, but of greater value is the detailed discussion of the fundamentals of these methods. Perhaps the most disappointing chapter in the book is that devoted to the materials used, i.e., the concrete and steel, but it is only disappointing in that it is too brief. This could with advantage have been expanded to deal with the various factors which influence the creep and shrinkage of the concrete. Useful data are presented on friction effects of the cable; little or nothing has been published on this subject, although it was raised many times in a recent symposium on prestressed concrete.

The book also contains a useful chapter on the "end blocks" of beams prestressed by means of cables, together with tables which simplify the calculations. The only previously published attempt at tackling this important problem was Professor Magnel's.

The short section devoted to pretensioned beams is one of the most succinct and useful contributions to the subject yet made. It is largely reprinted from one of Monsieur Guyon's articles published some years ago by the Institut Technique du Batiment et des Travaux Publics, but now long out of print. It analyses thoroughly the effect of placing the wires at different points in the cross section of the beam and gives an easy method of determining the best positions for the wires once the eccentricity is known. This method has been largely neglected by British engineers, but it is one which gives the most satisfactory results in practice.

The method of setting out the calculations and the symbols used throughout the book are simple to understand. This is a welcome relief from present-day literature on prestressed concrete, which usually contains large numbers of incomprehensible symbols. The book contains a useful, but perhaps rather verbose, chapter on tests of prestressed concrete beams and derives a simple yet accurate enough formula for determining the failing moment of such beams. In short, the book rightly shows the simplicity of prestressed concrete design and practice and, at the same time, examines critically a great number of points which the average engineer passes by without further thought. It is therefore a book to be welcomed. It is to be hoped that a further book will be forth-

coming by the same author on continuous structures in prestressed concrete since it is in this field that this form of construction has yet to be fully proved.

Rockets, Missiles and Space Travel. By WILLY LEY. London: Chapman and Hall, Ltd. 37, Essex Street, W.C.2. Price 30s.

THE recent announcement that small animals have ascended in V2 rockets to the fringe of the earth's atmosphere indicate some of the progress which has been made in high-altitude research since the appearance of the first English edition of Ley's book three years ago. A two-step rocket penetrating into space some 250 miles above the surface of the earth, and animal life suffering no ill consequences from the conditions of free fall, appear to show that this subject is becoming more and more one which will soon affect many engineers, especially those who will be called into the rocket missile programme. Consequently, a second enlarged edition of Ley's book arrives at a most opportune moment, when the guided missile defence programme is being rapidly stepped up and the demand for information concerning "this rocket business" far exceeds the supply of material.

The book maintains the high standard of its predecessor; and because it includes so many of the fascinating new developments of high-powered rockets it provides excellent background material for the serious engineering student who is interested in the subject. The criticisms made of the previous edition have been rectified and units are standardised by employing both the c.g.s. and f.p.s. systems throughout.

An extension of the title indicates the further scope of this new edition. The excellent historical background of the idea of space flight and development of the rocket is consolidated by a wealth of information on German and other guided missiles and such modern American rockets as the "Bumber WAC," "Aerobee" and "Viking." It seems rather a pity that some of the material from the appendices is not incorporated in the main body of the work. Indeed, one gets the impression of almost starting another book when, after dealing with problems of the lunar base, there is a swift return to earth in the first appendix describing the development of rocket aircraft.

There are one or two points which would appear to need correction. In Fig. 8, for example, it is hard to imagine how the solid-fuel rocket case could be inserted on to the central spindle, let alone be removed when loaded. Surely, too, the aircraft which was capable of chasing and matching the speed of the flying bomb was the "Tempest," not the "Spitfire"? On the matter of the earth-satellite vehicle it appears that Ley has missed the important point—as so many other writers have done before. Although the earth's bulge does not distort the orbit appreciably from a circle, it still plays havoc with the plane of the orbit if it is inclined to the equatorial plane. The nodes regress in a fairly short period measured in days for the close orbit, and the path over the earth's surface is quite different from the simplified version of Fig. 53. Finally, one wonders whether Ley's conclusion on the invulnerability of the military base on the moon can be really serious! The inadequacy of search radar to detect such a small object as a missile carrying an atom bomb would appear to be without doubt. There is, indeed, a world of difference between bouncing radar pulses from a globe the size of the moon (as quoted) and a small missile presenting a cross-sectional area of a few square feet.

But all in all the book is a "must" for all those connected with the engineering aspects of rockets. Its almost perennial appearance, first in the United States and now in England, tells us that there must be a great number of people interested in the wider aspects of rocket propulsion, this new technology which will soon free man from his terrestrial environment and his earthbound way of thought.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

PRESENT-DAY LOCOMOTIVE WORKING IN GREAT BRITAIN

SIR,—Since the publication of my article on the working of the "Britannia" engines in your issue of April 14, 1952, Mr. L. P. Parker, motive power superintendent of Eastern Region, British Railways, has written to me to point out that composite duty rosters have been worked by these engines since their first arrival in East Anglia, and that some of the diagrams involve quite long daily mileages. The portion of my article dealing with rostering may have been misleading on this point, although it did refer specifically to the earliest work of these engines. Mr. Parker has been kind enough to supply me with details of the five Stratford and six Norwich diagrams worked by these engines, and, at the same time, he points out that they include, for balancing purposes, three classes of fitted freight trains, and two classes of unfitted freight trains. Thus, the "mixed traffic" characteristics of the locomotives are well utilised.

The workings are:

Diagram	Length of time out of shed, h. min	Mileage
Stratford 1	17 23	486
Stratford 2	20 45	477
Stratford 3	19 27	368
Stratford 4	19 41	368
Stratford 5	15 22	148
Norwich 1	12 46	238
Norwich 2	19 18	460
Norwich 3	13 26	238
Norwich 4	20 17	460
Norwich 5	18 42	362
Norwich 6	9 23	239
Average	16 27	348

O. S. NOCK

Bath, May 17th.

SIR,—May I add to the comments which were made in Mr. Jolliffe's letter of April 22nd. Referring to the "Britannia" class, his experiences with severe longitudinal vibration apply with equal validity to the newer and generally similar "Clan" class. The most uncomfortable journey which I can recollect was when travelling in the second coach of a fast train hauled by one of these locomotives on the main line out of Euston a few weeks ago. On other occasions, no uncomfortable sensations have been experienced in the fourth coach or rearwards behind these locomotives.

Mr. E. S. Cox, in his recent paper to the Institution of Locomotive Engineers, put forward, amongst others, the following reasons for the adoption of two-cylinder propulsion. They include the procuring of greater simplicity together with improved accessibility, the elimination of a crank axle, which is an expensive component to manufacture, as well a doing without split big-ends, which are not easy to maintain. Mr. Cox claimed that as "Britannia" class engine would have cost an additional £1000, with an increased weight of 3½ tons, had three cylinders been provided instead of two.

In their early days at any rate, the Great Western "Counties" had a habit of communicating a punching sensation to passengers in the front coaches of trains. I have not travelled close behind one of these engines in recent years, but have certainly never heard of any bad teething troubles with this class.

JOHN FOX
M.I.Mech.E., A.I.Loco.E., F.Inst.P.

Hove, May 3rd.

THE "BRITANNIA" LOCOMOTIVES

SIR,—Apart from Mr. Keller's letter of April 11th, there has not been a single comment on your leading article of April 4th. Those most favourably placed to comment on your article and on Mr. Keller's letter maintain a discreet silence—possibly in the hope that the defects which manifested themselves may be forgotten. It may be permissible to wonder how much of the complete silence "of understanding and sympathy" on the part of the technical Press was due, in reality, to the silence of those in possession of the facts.

As Mr. Keller said, "roller bearings themselves may not be the culprits, but rather the method of mounting," and by "mounting" is meant not the actual housing of the bearings, but the practice of using hard contact surfaces between axleboxes and horn blocks in place of the old combination of cast iron, or steel, horn blocks and white-metalled rubbing surfaces of the axleboxes.

In some quarters it has been suggested that slipping at speed was due to the use of roller bearings. Surely a fantastic suggestion. In all probability when running at speed there is little difference between well-lubricated plain bearing and roller bearing axleboxes. In the past advocates of roller bearings for coaching stock were met with the argument that roller bearings only offered an advantage when a train was started and static friction had to be overcome. Is it seriously suggested that the margin of safety for the forced fit of a driving wheel on its seat is so narrow that the reduction in friction effected by roller bearings can give rise to relative movement between wheel and seat?

Your leading article states that in an attempt to cure the trouble the hollow axles have been plugged and that the coupling-rod section has been changed. The object of the latter expedient is to reduce the weight, presumably, although fluted rods have been adopted in the past because they were lighter than plain rods of equal strength. A plain rod compares unfavourably with a fluted rod when considered as a strut and as a beam.

The plugging of the axles for the length of the wheel seats seems more to the point, and in this connection the discussion on built-up crankshafts, reported on page 543 of the issue of April 18th, is very interesting. The discussion was reported from the spring meeting of the Institution of Naval Architects, and it referred to slip in built-up crankshafts. It may well be that the slip between wheels and seats in the "Britannia" locomotives was due to design factors and that a higher factor of safety in estimating the coefficient of friction might have eliminated the source of trouble.

Professor Scott referred to the remarkable effect of the nature of the lubricant used in the force fitting of wheels and axles. With tallow as a lubricant the grip of the wheel on the axle was found to be only a fraction of that obtained when spindle oil was used. Interface conditions are of great importance—what attention is given to these conditions in railway practice, and what part does rule-of-thumb play?

E. B. PARKER

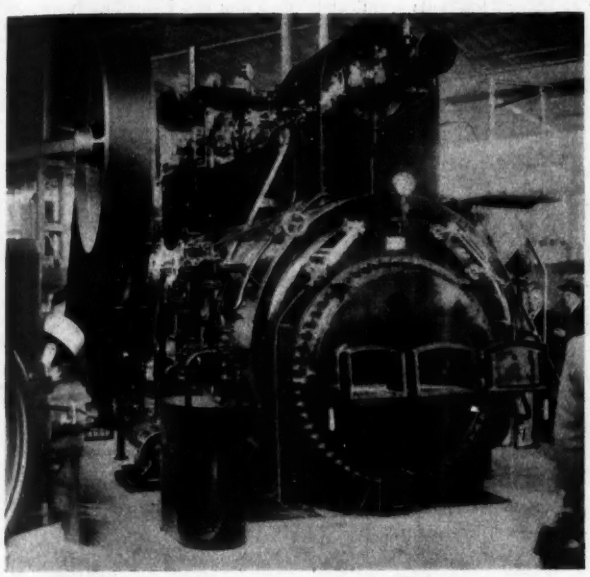
Wirral, May 17th.

Hanover Technical Fair

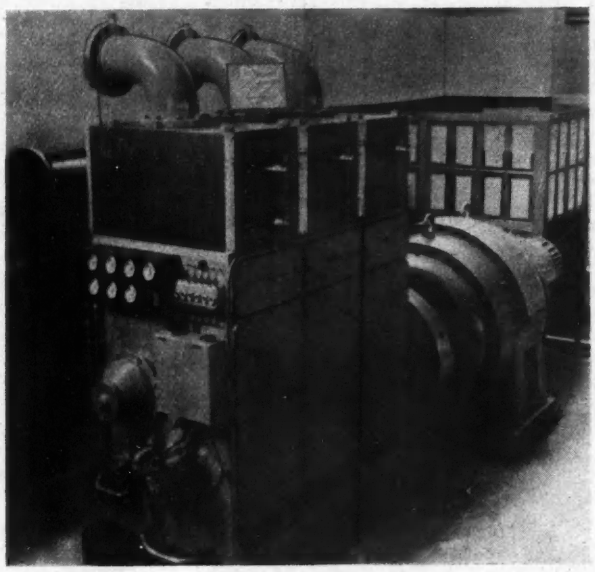
No. II—(*Continued from page 663, May 16th*)

DURING the ten days of the Fair the attendance was more than 800,000. Among the visitors were 55,000 from abroad, about 10 per cent more than last year; South America was particularly well represented by delegations from the Argentine, Bolivia, Brazil, Chile, Columbia, and Ecuador. In 1953 the Technical Fair will be held from April 26th till May 5th.

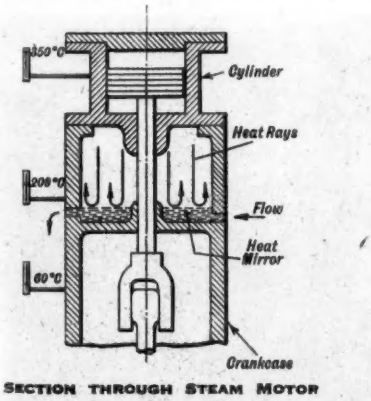
Large oil engine builders only show in alternate years, and this year the smaller sizes of engines were on view. It was interesting to note that the firm of Maschinenfabrik Buckau R. Wolf A.G., of Magdeburg, has now established itself at the works of the Maschinenfabrik Grevenbroich, Rhine, with which for many years it has been associated, its main offices being at Neuss Königstrasse, I. A full programme of construction of steam boilers and engines has been undertaken, together with plant for brown coal briquetting, sugar factories and drying installations. The firm showed one of its improved single-cylinder "locomobile" steam units arranged for either exhaust or back-pressure working. It has a working pressure of 15 atmospheres, the normal rating being 240 h.p. with a continuous rating of 300 h.p. and 360 h.p. for short periods. The boiler, with a steam output of 2500 kg per hour, has a heating surface of 82 square metres and the ring pattern superheater fitted has a surface of 75 square metres. The coal consumption is stated to be 0·84 kg per horsepower, and the steam consumption 6·9 kg per hour. The boiler is completely welded and has a single long flue with water tubes, the surface being divided in the ratio of two-thirds for the flue and one-third for the tubes, as against the opposite ratio used in earlier designs. The ring superheater is arranged in a separate chamber, which gives better access to the tubes for cleaning. Two soot blowers, one for the tubes and one for the superheater, are provided. The fully enclosed engine is no longer riveted to the boiler, but is supported on two brackets reaching to the centre of the boiler and carried down to ground level in all the larger sizes of engine. The new support gives a very steady unit, and it is now possible to insulate fully the top of the boiler. As illustrated herewith, the piston-rod has a front guiding bearing. The engine described is made in powers from 70 h.p. to 450 h.p. with boiler outputs of 740 kg to 3700 kg per hour. Twin engine units with two high-pressure cylinders are built up to 800 h.p. and boiler outputs of 5000 kg per hour. For high back-pressure working pressures up to 18 atmospheres are used.



300 H.P. "LOCOMOBILE"

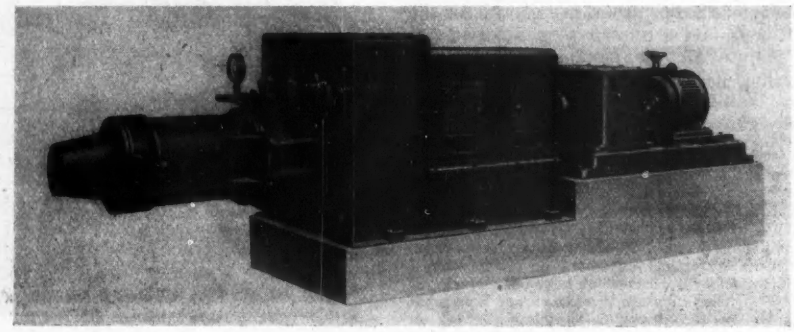


300-375 H.P. STEAM MOTOR WITH GENERATOR



SECTION THROUGH STEAM MOTOR

The Spillingwerk Maschinenfabrik, of Werftstrasse 5, Hamburg, II, exhibited a three-cylinder engine, coupled to a generator. The engine has a rated output of 300–375 h.p. at 750 r.p.m. In the new design shown in our illustration, the usual gap left between the top of the crankcase and the underside of the cylinders has been eliminated, giving a completely enclosed engine. At the bottom of the enclosed space there is a flowing film of water, which reflects the heat rays coming down from the cylinder and forms a self-cooling heat mirror. The arrangement is shown in the drawing. The Spilling steam motor is constructed in two series, one having a rated output of 25 h.p. per cylinder and the other 100 h.p. per cylinder. They are built in single units and can be readily assembled to form from a single cylinder up to a six-cylinder unit, if needed. A further 130 h.p. unit is available for five and six-cylinder engines for the larger powers. All working parts of these units are interchangeable. The running speeds are 1500 r.p.m. for the smaller powers, 1000 r.p.m. and 750 r.p.m. for the higher powers. A sensitive governor serves to keep a steady speed for driving an electrical generator, and as 90 per cent of the moving masses are balanced quiet running is assured. The short stroke of 70mm to 140mm gives a piston speed of only 3·5m per second. This compares favourably with earlier steam engines of 4m to 4·5m per second and with the diesel engine piston speed of about 7m to 9m per second. The Spilling steam motor is finding increased use in industrial power

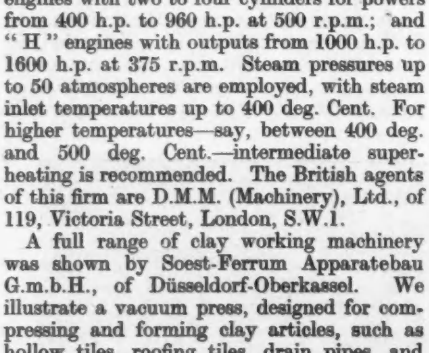


VACUUM PRESS FOR CLAY WORKING

installations requiring process steam and for marine services, such as auxiliaries for pump or dynamo driving.

In its special pavilion the Maschinenfabrik MEER A.G., of München-Gladbach, exhibited one of its 660 h.p. three-cylinder enclosed steam engines, designed for exhaust or back-pressure operation, arranged for driving a dynamo. The three designs offered by the firm include "B" engines of single up to four cylinders, with designed outputs of 60 h.p. to 340 h.p. at 750 r.p.m.; "E" engines with two to four cylinders for powers from 400 h.p. to 960 h.p. at 500 r.p.m.; and "H" engines with outputs from 1000 h.p. to 1600 h.p. at 375 r.p.m. Steam pressures up to 50 atmospheres are employed, with steam inlet temperatures up to 400 deg. Cent. For higher temperatures—say, between 400 deg. and 500 deg. Cent.—intermediate superheating is recommended. The British agents of this firm are D.M.M. (Machinery), Ltd., of 119, Victoria Street, London, S.W.1.

A full range of clay working machinery was shown by Soest-Ferrum Apparatebau G.m.b.H., of Düsseldorf-Oberkassel. We illustrate a vacuum press, designed for compressing and forming clay articles, such as hollow tiles, roofing tiles, drain pipes, and similar articles. In the new design of this machine two kneading arms with slicing plates arranged over the feed screw effectively knead the clay and force it through adjustable discharge openings into the feed screw chamber. The clay is driven forward by two arms or vanes, which feed it into the vacuum chamber. At this point the clay is further pulverised, broken up and freed from air by a serrated screw. It is then forced by the screw and vanes through the mouthpiece, whence it issues as amorphous material, free from air bubbles.



RAPID BUILDING WINCH

The manufacture of Schiess-Defries winches and lifting gear has been reestablished. A good example of the new exhibits is the rapid building winch, illustrated above. It has a designed lifting capacity of 600 kg to 750 kg and has a single control handle. A main and auxiliary lifting gear for a travelling crab was also shown, having a capacity of 32 tons at 5m per minute for the main hook and 8 tons at a speed of 12·5m per minute for the auxiliary hook. The travelling speed is 25m per-minute. All the gears, both for lifting and for travelling, are totally enclosed and run in an oil bath.

(To be continued)

FENCING OF PRESS BRAKES.—The Joint Standing Committee on Safety in the Use of Power Presses has published a report on safety in the use of press brakes. The report illustrates and describes a number of safety devices which have been developed largely by users of press brakes, and it lays great emphasis on the importance of maintaining in efficient condition parts of machines such as brakes and clutches.

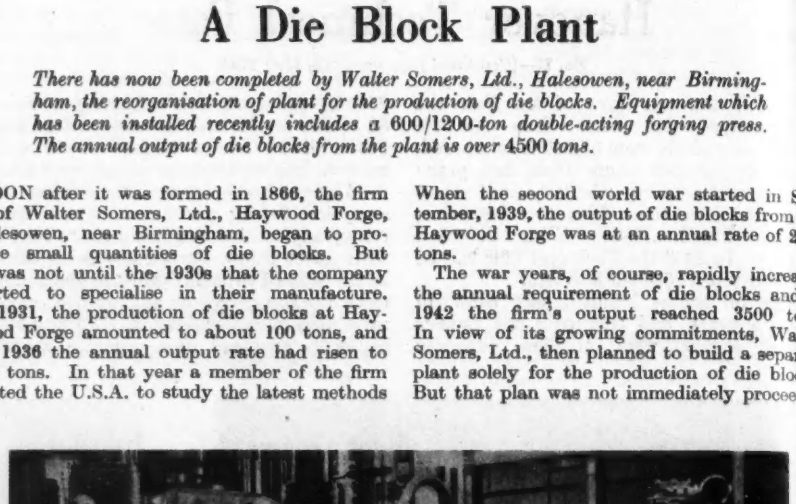
A Die Block Plant

There has now been completed by Walter Somers, Ltd., Halesowen, near Birmingham, the reorganisation of plant for the production of die blocks. Equipment which has been installed recently includes a 600/1200-ton double-acting forging press. The annual output of die blocks from the plant is over 4500 tons.

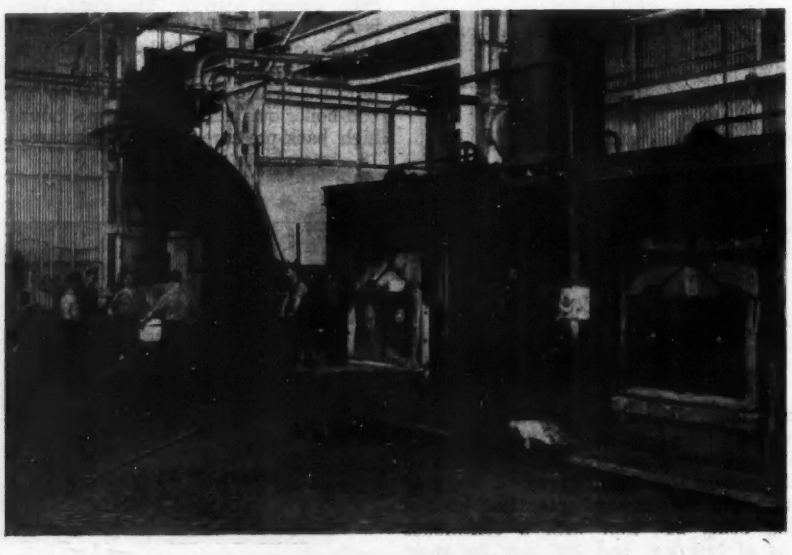
SOON after it was formed in 1866, the firm of Walter Somers, Ltd., Haywood Forge, Halesowen, near Birmingham, began to produce small quantities of die blocks. But it was not until the 1930s that the company started to specialise in their manufacture. In 1931, the production of die blocks at Haywood Forge amounted to about 100 tons, and by 1936 the annual output rate had risen to 750 tons. In that year a member of the firm visited the U.S.A. to study the latest methods of die block manufacture there, and as a result there was purchased from the Alliance Company of Ohio a 5000 lb forging manipulator—illustrated herewith—which was installed at the Haywood Forge early in 1937. About the same time the firm also installed heat-treatment furnaces, quenching tanks and testing equipment suited to a new production technique which was introduced by arrangement with the Heppenstall Company, of Pittsburgh, U.S.A.

When the second world war started in September, 1939, the output of die blocks from the Haywood Forge was at an annual rate of 2500 tons.

The war years, of course, rapidly increased the annual requirement of die blocks and in 1942 the firm's output reached 3500 tons. In view of its growing commitments, Walter Somers, Ltd., then planned to build a separate plant solely for the production of die blocks. But that plan was not immediately proceeded with as it was concluded—correctly as it transpired—that the war would probably be over before the benefits from such a plant could be realised. At the end of the war, the company had at its disposal a section of the works at Halesowen which had been lent to the Ministry of Supply for the manufacture of projectiles, and there it was decided to concentrate all the existing equipment concerned in the production of die blocks and to install



FORGING MANIPULATOR



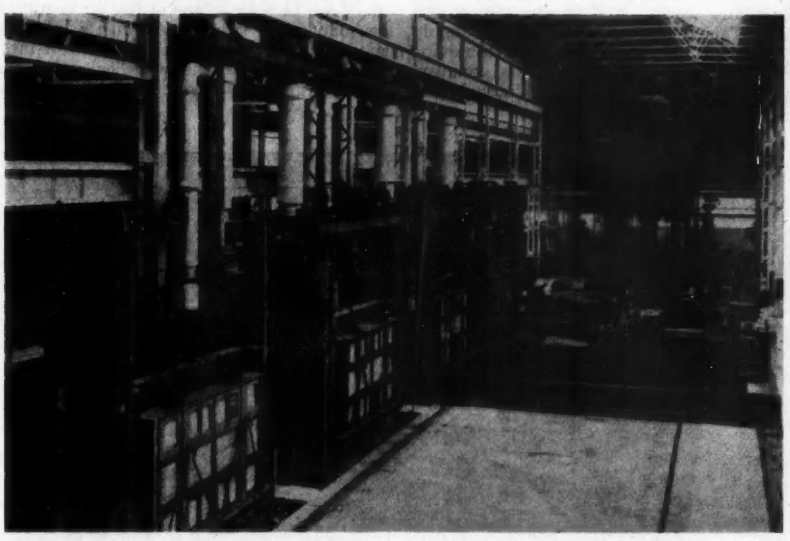
30-CWT COMPRESSED AIR HAMMER

such additional plant as was necessary. The die block section, as it is now known, has its own offices and canteen, and was officially opened on Wednesday of last week by Admiral Sir William Tennant, K.C.B., Lord Lieutenant of the County of Worcester. Prior to the ceremony, a large company of guests was entertained at a luncheon at which Mr. Seth Somers, chairman of Walter Somers, Ltd., and the son of the founder of the business, presided.

The die block plant has been arranged in such a way as to maintain a general flow of material throughout; there is thus no need for products, at any stage during processing, to return over ground already covered. Roller conveyor track has been installed to link up all the processes of manufacture. About the middle of 1948, a 30 cwt compressed air hammer, supplied by B. and S. Massey, Ltd., was added to the plant, and other new equipment installed about the same time included a shot blast room for scale removal, four electric heat-treatment furnaces, and water and oil quenching tanks. The furnaces are served by a 5-ton Gibbons van Marle revolving charging machine, which is mounted on rails running the full length of the heat-treatment shop. Two of the photographs which we reproduce show the 30 cwt hammer, and the 5-ton charging machine for the heat-treatment plant. The inspection, testing and machining plant had been transferred to the new shop by the end of 1948, thus providing facilities for the production of die blocks up to 300 lb each. The company then proceeded with its plans for the completion of the plant.

During a post-war visit to Germany, representatives of the company inspected a hydraulic forging press capable of working at two power stages of 600 tons and 1200 tons respectively. It was built by Schloemann A.G., of Dusseldorf, and during the war had been in operation in the Rheinmetall Borsig works, near Dusseldorf. Some damage had been done to the press by R.A.F. bombing attacks, but the makers found it possible to effect the necessary repairs and to supply missing parts. Ultimately, the press was acquired by Walter Somers, Ltd., and it was brought to Halesowen, where it was re-erected under the supervision of the Schloemann company's engineers. At the same time an order was placed with Schloemann A.G. for the hydraulic installation.

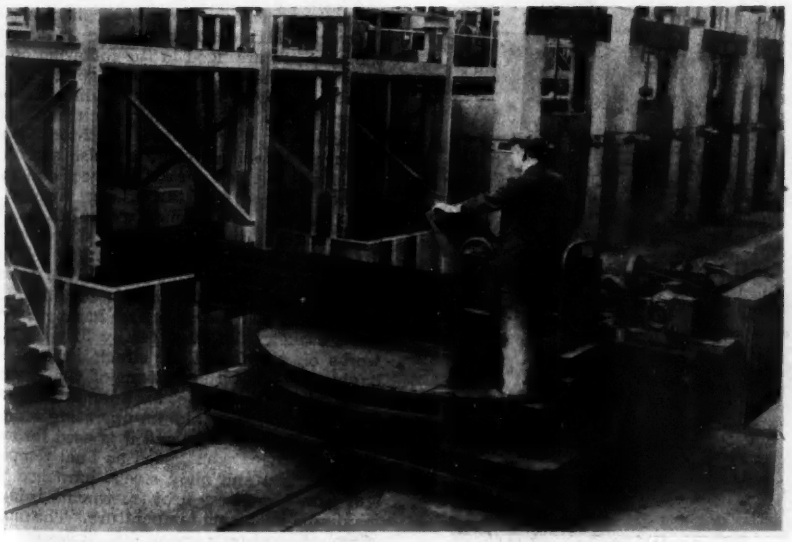
At the base of the press an anvil is arranged, which can be moved in both directions to permit quick changing of the tools and also rapid feeding and removal of the forgings. Two hydraulic locking gears—one at either side of the bottom platen—enable the moving anvil to be securely locked in the central forging position. The main ram is rigidly connected to the moving crosshead, so that eccentric forces are intercepted chiefly by the long piston guide bush in the main cylinder. Guide sleeves, mounted spherically in the lugs of the moving platen, preserve the four press columns from wear and tear in case of eccentric forging, by avoiding edge pressure on the sleeves. The press rams are operated by Schloemann quick-acting valve gear, the valves being actuated by a hand lever without a servo-motor. The water pressure station which feeds the press consists of a pistonless air-hydraulic accumulator, which has a useful water capacity of 110 Imperial gallons, and two horizontal three-throw pressure pumps, each capable of delivering 111 Imperial gallons a minute against a working pressure of 2850 lb per square inch. The pumps are driven by two electric motors which were supplied by the General Electric Company, Ltd. The pressure water station is situated in a side building of the main forge, and is thereby well protected from dust. To exert a pressure of 600 tons, the press is fed with pressure water of 2850 lb per square inch working pressure, the second stage of 1200 tons being reached by feeding pressure water of a working pressure of 5700 lb per square inch. Normally, ingots up to a piece weight of 16 tons can be forged on the press, though it is understood that most of the work required from it will not exceed 4 tons in weight. To serve the press, five oil-fired reheating furnaces with a total hearth area of 400 square feet have been installed by Urquharts, Ltd. It was realised that these furnaces would heat steel to forging temperature more quickly than it could be dealt with by hand-manipulated equipment, and, consequently, the plant now includes a 4-ton, low-floor revolving furnace-charging machine, supplied by the Wellman Smith Owen Engineering Corporation, Ltd., which charges the furnaces and conveys heated steel to the anvil of the press where the forging manipulator takes over. This machine is equipped with push-button control for the raising and lowering of the furnace doors. The view of the forge bay which we reproduce shows the 600/1200-ton press, the reheating furnaces, and also the 4-ton charger.



FORGE BAY WITH 600/1200 TON PRESS

When the assembly under one roof of the die block plant was first put in hand, the heat-treatment equipment consisted of four electric furnaces, with water and oil quenching tanks. The heat-treatment plant has now been doubled, four furnaces being used for hardening and four for tempering. All the furnaces were supplied by Birlec, Ltd. Two large cooling pits, each capable of holding over 50 tons of die blocks, have also been installed.

By reorganising the plant and bringing the new equipment into operation, the production of die blocks at the Haywood Forge has now been increased to more than 4500 tons a year. That figure, the company says, is still well below capacity output.



5 TON REVOLVING CHARGING MACHINE

INDUSTRIAL PHYSICS CONFERENCE.—The fourth conference on Industrial Physics, arranged by the Institute of Physics, will take place at the Royal Technical College, Glasgow, from June 24th to 28th next. The subject of the conference is "Physics in the Transport, Shipbuilding and Engineering Industries." In connection with the conference an exhibition of instruments, apparatus and books relevant to this subject will be held and more than seventy industrial firms and Government departments have accepted invitations to take part. It is expected to be one of the largest displays of scientific instruments and apparatus that has been held in Scotland. The programme of the conference includes lectures and discussions on metal physics, meteorology, the education and training of industrial physicists in Scotland, sound reproduction, physics in naval architecture, physics in transport, automatic control of industrial processes, and noise and its suppression. The conference will be opened by Lord Bilsland, president of the Scottish Council, and the speakers include Sir Andrew McCance, chairman of the organising committee of the conference), and Sir Robert Watson-Watt. Full particulars, forms of application for conference membership and tickets of admission to the exhibition may be obtained from the Secretary, the Institute of Physics, 47, Belgrave Square, London, S.W.1.

A Gear Cutting and Heat Treatment Plant

IN 1947, when it was found that the increasing range of earth-moving and contractors' plant it was making and planning to introduce was getting beyond the capacity of its Watford works, Blaw Knox, Ltd., of 90–94, Brompton Road, London, S.W.3, acquired a large section of the Short works at Rochester for a new factory. This Rochester works is now mainly concerned with the production of earth-moving equipment, such as graders, scrapers, &c., and power control units, whilst at Watford constructional equipment, including concrete mixers, batchers, excavators, dozers, &c., are built.

The original production floor area of 85,000 square feet at Rochester has been extended from time to time as the range of plant increased, and it now covers some 95,000 square feet, as well as a large open storage and erection yard. The most recent extension is a new heat-treatment shop, which has been laid down in conjunction with a gear cutting section in the machine shop. These two new sections of the works have been introduced to overcome a major bottleneck in production occasioned by difficulties in obtaining sufficient supplies of gears from outside sources. Large numbers of gears are required for the motor graders in particular, and to keep pace with the steadily increasing demand for these machines and other plant, means of maintaining a regular supply of gears became essential.

This gear cutting section of the machine shop can be seen in one of the photographs we reproduce. It is equipped with a selection of modern plant for the manufacture of internal and external spur wheels, helical gears, worms and worm wheels, and straight and curved bevels. A spline grinding machine and a horizontal broaching machine also form part of the equipment in this section, as many of the gears have splined bores. After heat-treatment the gears are ground in their bores and faces, but not over their teeth. Precision equipment has been installed to control the quality of the gears, which are all tested both before and after heat-treatment.

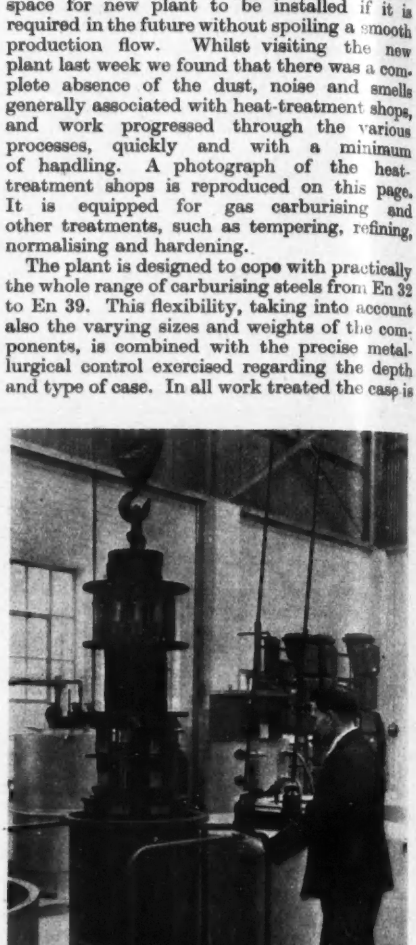
The heat-treatment shop, which is 65ft long, 35ft wide and 22ft high to the crane girder, has been erected on a site dug out of the side of a large escarpment adjoining the main shops. In its layout and equipment the engineers of Blaw Knox, Ltd., worked in close collaboration with Wild-Barfield Electric Furnaces, Ltd., of Watford, Herts, which supplied and installed a majority of the plant. This close co-operation between the users and makers of equipment from the very outset has resulted in the laying down of a model heat-treatment shop with ample capacity for present requirements and space for new plant to be installed if it is required in the future without spoiling a smooth production flow. Whilst visiting the new plant last week we found that there was a complete absence of the dust, noise and smells generally associated with heat-treatment shops, and work progressed through the various processes, quickly and with a minimum of handling. A photograph of the heat-treatment shops is reproduced on this page. It is equipped for gas carburising and other treatments, such as tempering, refining, normalising and hardening.

The plant is designed to cope with practically the whole range of carburising steels from En 32 to En 39. This flexibility, taking into account also the varying sizes and weights of the components, is combined with the precise metallurgical control exercised regarding the depth and type of case. In all work treated the case is entirely free from hypereutectoid and use is made at all times of a controlled atmosphere in order to avoid scaling and the consequent necessity of shot blasting or pickling of parts.

Over an 11ft. deep pit running the length of the shop are arranged in the following order a loading station, a cooling pot, a gas carburising furnace, a cooling pot, an unloading station, a water quench tank, an oil quench tank, and a vertical tempering furnace. A 2-ton capacity overhead travelling electric hoist serves the full length of this group of furnaces and tanks.

The vertical gas carburising furnace set between the two cooling pots has a work chamber, 24in diameter by 48in deep, and it is fitted with nickel-chromium alloy elements giving a maximum rating of 100kW. Its maximum operating temperature is 1000 deg. Cent. The vertical tempering furnace has a removable work basket, 32in diameter by 32in deep. It works on the forced air circulation principle, having a fan at the bottom of the chamber, which circulates the hot air around the work in the basket. Its maximum operating temperature is 700 deg. Cent., and it is used for subsequent heat-treatment, such as final tempering of carburised and alloy steels, hardened work and general-purpose heat-treatments below its maximum operating temperature. The method of mounting gears, pinions, &c., in jigs for treatment can be seen in another of our illustrations,

GEAR CUTTING SHOP



REMOVING JIG FROM RETORT

HEAT TREATMENT SHOP

where a loaded jig is being removed from a retort at the unloading station.

On one side of the shop is a Wild-Barfield horizontal "Hairpin" furnace fed with a controlled atmosphere. This furnace has a working space 40in. wide by 18in high and its maximum operating temperature is 1050 deg. Cent. In addition to being used for subsequent refining and hardening after gas carburising, it is also used without atmosphere for the normalising of rough forgings before machining, for gas carburising and the hardening with atmosphere of carbon and alloy steels. Parts to be treated in this furnace are arranged on trays placed on a roller-tipped trolley, which can be wheeled up to the furnace door for the trays to be quickly and easily slid into the chamber.

A gas preparation unit and a Holmes catalytic sulphur removal plant are installed for the removal of organic sulphur compounds from the town's gas before it enters the furnace chamber. These units, together with salt baths and a degreasing unit supplied by I.C.I., Ltd., are arranged by the side walls of the building, where they are accessible but clear of the main working area. At the far end of the shop are a small laboratory and a control office for the plant, which are at present being equipped.

Report on the Fire on the "West Riding" Express Train

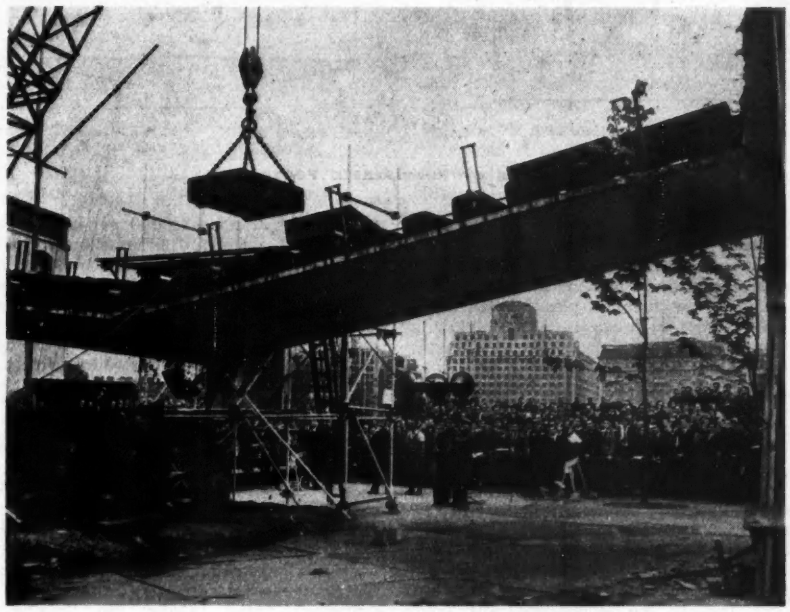
WHEN the 3.45 p.m. "West Riding" express train from King's Cross to Leeds was near Huntingdon on Saturday, July 14th last, a fire occurred in the second coach when the train was travelling at about 55 miles an hour. The train was stopped by an emergency application of the brakes, and as a result of the fire spreading four coaches were eventually completely destroyed and twenty-two passengers received burns or other injuries in escaping from the train. The Ministry of Transport report on the fire says that fumes from the back of a seat, which were the first indications of the fire, were noted by passengers at about 4.30 p.m., and as the fumes continued to get worse the communication chain was pulled. When the train had been halted flames appeared and spread rapidly and in a few seconds reached the roof and travelled along it at some considerable speed. In a short time the fumes and flames spread to the coach in front, and eventually the four front coaches of the train, which had by that time been uncoupled, were destroyed by the fire. The report states that there is little doubt that the fire started in the hole in the floor through which the air duct to the toilet was taken, and was in all probability caused by a piece of live coal from the engine. The fire was similar in two main respects to three other fires on trains in recent years, in that it spread with extreme rapidity inside the coaches and that the design of the coaches rendered the escape of passengers difficult. The inspecting officer remarks that a number of facts about the fire stand out clearly: it would have been prevented altogether if the asbestos packing between the edges of the holes in the floor and the air duct had been in place, and the rapid spread of flames would not have occurred if the interiors of the coaches had not been covered with highly combustible materials. The danger to passengers and the injuries they received would have been avoided if the fire extinguisher had worked; if the communication chain had been readily available in the coach; if the train crew had stopped the train promptly when told of the fire; and if there had been a sufficient number of exits available to permit reasonably rapid evacuation.

BAKELITE PLASTICS CATALOGUE.—We have received from Bakelite, Ltd., Grosvenor Gardens, London, an illustrated catalogue describing the properties of its products and their application. It commences with an account of the thermo-setting moulding powders, and illustrates some of the many products which are made from it. One section deals with "Warite" laminates which are primarily used for decorative purposes. The catalogue concludes with a description of the "Vybak" thermo-plastic range of extrusions, mouldings and calendered sheeting.

Testing a Prestressed Concrete Bridge

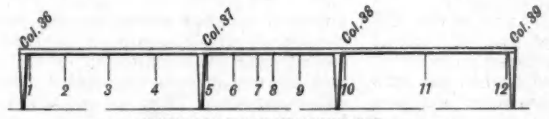
IN the Seven-Day Journal of our issue of May 9th, reference was made to the testing of a prestressed concrete footbridge at the South Bank exhibition site in London. The complete results of the test are now available, and are embodied in the load-deflection curves reproduced in two of our illustrations herewith.

The bridge was described in our issue of May 4, 1951. It had a total length of 284ft and its general construction is indicated in the illustration on page 708. The columns, which are not shown in this illustration, were tapered from a section of 3ft 9in by 2ft 3in at the top to 1ft 9in by 1ft 6in at the base; the column at the angle was slightly thicker. The columns were founded on individual reinforced concrete bases 1ft 6in deep and measuring, for the four standard columns, 12ft by 8ft 6in and for the larger, 16ft by 8ft 6in, which spread the load to a maximum bearing of half a ton per square foot. The columns at each end of the footbridge and the centre column were built with a hinge at top and bottom, to take up the movement due to prestressing the deck. On completion of the prestressing, the hinges were grouted, and were then considered as "encastré" at top and bottom.

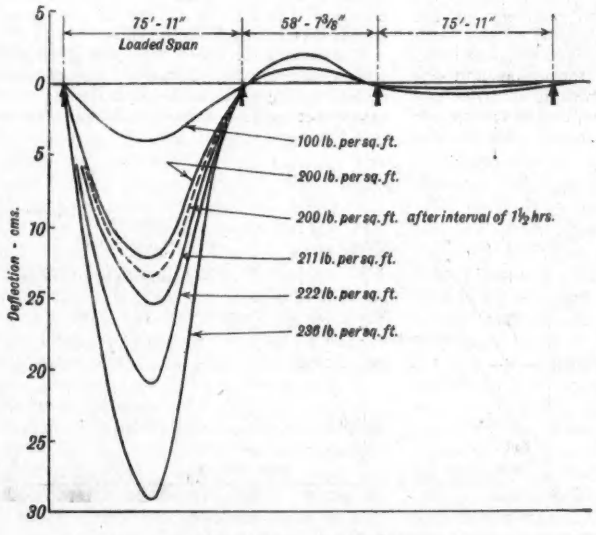


FAILURE OF THE BRIDGE

Construction was carried out in two stages. The first span, between columns 36 and 37, and approximately half the second span, which was constructed as a cantilever, were built first. The second stage took in the whole of the remaining "dog-legged" portion up to the Concert Hall terrace, including, again, just under half the second span as a cantilever. When the two sections were completed and eighteen of the twenty-four longitudinal cables were stressed, the 4ft centre gap was joined up and the remaining six cables then tensioned. The Freyssinet system of prestressing was used, and the bridge was designed for a load of 100 lb per square foot between the handrails.

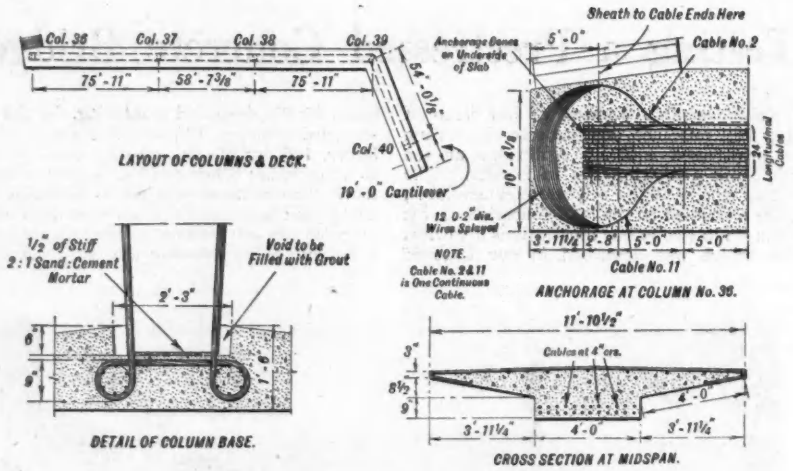


POSITION OF 12 DEFLECTION GAUGES.



DEFLECTION PROFILES

The specification required an average concrete strength of 4000 lb per square inch at the time of stressing (five to seven days) and 6000 lb per square inch at twenty-eight days. Average results of cube tests gave 4580 lb and 6320 lb per square inch at six and twenty-eight days respectively. The contractors for the footbridge were Kirk and Kirk, Ltd., and the



DETAILS OF PRESTRESSED FOOTBRIDGE

consulting engineers Ove Arup and Partners. The overall consultants for the Festival site were Freeman Fox and Partners. Maxwell Fry, Jane Drew and Partners, architects of the Waterloo Bridge entrance, planned this bridge as part of the same design.

THE TESTS

Briefly, the tests comprised the following:—(*a*) behaviour of the bridge at design load, (*b*) recovery after 150 per cent liveload, (*c*) recovery after 200 per cent liveload, (*d*) to determine the maximum load the bridge would carry before collapse. The end span, adjacent to Waterloo Bridge, was loaded with kentledge and the testing extended over a period of three days. The load was applied gradually and so distributed to approximate to the conditions of uniform loading, the blocks generally being 2½ tons each with the final loads in 3½-ton increments. Measurements of the deflections were taken in both the loaded and unloaded spans, at the twelve points shown in the diagram below.

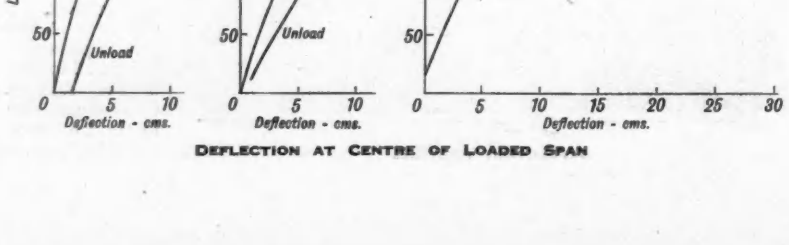
On the first day, April 29th, the bridge was loaded to the design liveload of 100 lb per square foot, then to 125 lb per square foot, and finally to 150 lb per square foot (50 per cent overload). Deflections were measured at each stage and the load was left on overnight and the change of deflection noted. These values were chosen as representative of the recommendation of the B.S. Code of Practice C.P. 114, "The Structural Use of Normal Reinforced Concrete in Buildings (Clause 605)," for the 25 per cent overload, and of the 1933 report of the Reinforced Concrete Structures Committee of the Building Research Board (Clause 1001) as regards the 50 per cent overload.

On the second day the recovery of the structure was noted on removal of the load, and it was then reloaded to 100 per cent overload, studying the crack formation and the deflections. This load was then removed and the recovery noted. On the final day, May 1st, the bridge was loaded to failure. During the morning loading up to 100 per cent overload was carried out, and after a one and a half hour interval loading was continued to destruction.

From the deflection readings, the curves of deflection against equivalent uniform liveload illustrated herewith, were plotted, the equivalent load w having been calculated by equating the bending moment at the centre of a freely supported span of 76ft as calculated by the distribution of kentledge, to $\frac{wl^2}{8}$. The first load deflection curve shows the loading increased to 150 lb per square foot, left on overnight and then removed. Some doubt exists as to the extent of the overnight creep at the centre of the span as the gauge had been disturbed, which is confirmed by the smaller creep shown on the adjacent gauges at the quarter points. Excellent recovery is shown in the second load deflection curve, where the loading was increased to nearly 200 lb per square foot, and then removed on the second day. The final load deflection curve indicates the final day's loading to failure. A further curve has been drawn showing the deflection profile throughout the three spans from which it would appear that the continuity effect did not increase over the second support and beyond, after loading to 200 lb per square foot.

The structure carried a load of 84½ tons, which was equivalent to 236 lb per square foot uniformly distributed, and failed under a load of 88 tons (250 lb per square foot). Failure appeared to occur almost simultaneously over the second support and near the middle of the loaded span by compression in the concrete, and the end column was pulled over by the collapsing span. There did not appear to have been any general failure of the steel cables, but a noticeable feature after collapse was the absence of bond between the cables and the concrete due to the failure of the grout to penetrate through from the ends.

The testing of the bridge was arranged by the Cement and Concrete Association in collaboration with the London County Council and the consulting engineers, Messrs. Ove Arup and Partners.



DEFLECTION AT CENTRE OF LOADED SPAN

Reinforced Plastics Convention

LAST WEEK there was held at Ashorne Hill, Leamington Spa, a convention organised by Fibreglass, Ltd., on Glass Fibre Reinforced Plastics, at which eight papers were read.

The first paper, read by A. M. Dobson (Fibreglass, Ltd.), was entitled "Glass Fibre Reinforcements for Plastic Laminates." This paper dealt specifically with the use of various forms of "Fibreglass" reinforcement, with particular reference to resins of the polyester type.

A paper by Dr. V. E. Yarsley on "Some Chemical Aspects of Contact Resins," reviewed some methods of formation and general characteristics of the thermoplastic and thermosetting materials, together with the characteristic long chain polyesters, and some fundamental differences, particularly those in which chain formation results in the elimination of chemical waste products, were described.

In a paper entitled "Glass Reinforced Plastics in the Aircraft Industry," by G. C. Hulbert, the writer summarised briefly the general properties of the material, the forms of glass and types of resin available. The physical properties of glass reinforced materials impose certain limitations upon their introduction into traditional aircraft structures, and these were discussed. The effect of the present and potential supply position of home-produced glass fibre and resin on project designs of ambitious magnitude is also described. Following some general introductory aspects of glass fibre laminates in aircraft, H. Warburton Hall and G. A. Cellie, in their paper entitled "Some Applications and Problems of Glass-Fibre Laminates for Service Use," went on to discuss some of the problems associated with the general trend to exploit the characteristic properties of glass fibre laminates. They include increasing the tensile strength to weight by unidirectional fibre orientation and the use of finer filaments, the loss of mechanical strength with exposure to moisture and the development of "finishes" to overcome this defect, the need for high temperature-resistant laminates and laminates with rain erosion resistance. Supplying fully impregnated "dry" material, with reasonable shelf life, needing only to be tailored, laid up and pressed, was suggested. Another paper, "Fibreglass Based Laminates for Electrical Applications," by K. Hyde, discussed the general properties of fibre glass laminates and their manufacture for electrical applications.

In a paper entitled the "Relationship Between the Composition, Structure and Physical Properties of Glass," by H. Cole, a survey was given of the progress made in the continually developing subject of the theory of glass structure since the fundamental ideas first put forward by Zachariasen. The classification of glass constituents into such groups as network formers, intermediates, stabilising modifiers, and network modifiers, is to be regarded solely as a convenient, arbitrary arrangement. It is possible, however, to deduce which elements may be expected to take part in network formation on the basis of cation anion radius ratio and electronegativity differences. By means of such factors and a knowledge and understanding of the electronic configurations of all the component atoms of a glass, it has now become possible to predict the influence of a change in a glass composition on its properties. The durability of glass is related to the presence of mobile, reactive sodium ions, and the different actions of acid and alkaline solutions is explained on the basis of the polarisation of oxygen ions. Electrical conductivity is ionic in character and dependent chiefly on the mobility and freedom of passage of sodium ions. Dielectric properties were considered on the basis of ionic mobility, ionic vibrations and network deformations.

In another paper entitled "Applications of Reinforced Plastics in the U.S.A.," C. E. Bacon dealt under eight different headings with the application of plastics to fishing-rods, boats, boxes and trays, aircraft, domestic appliances, building material, furniture and automobiles. The other paper was concerned with "Methods of Manufacturing Reinforced Plastics in the U.S.A.," and was written by C. E. Bacon.

Iron and Steel Institute

No. III—(*Continued from page 679, May 16th*)

ON Thursday morning, May 1st, the following papers were discussed :—

AN EXPERIMENTAL FURNACE FOR THE INVESTIGATION OF OPEN-HEARTH FURNACE COMBUSTION PROBLEMS PART V—EXPERIMENTS WITH THE VENTURI PORT AND MODIFICATIONS THEREOF

By F. J. Allen

Synopsis

The effect on heat transfer of the position of the gas-port nose and the steepness of the ramp roof in ports of the Venturi type were examined. Improved results were obtained by moving the gas port back and by steepening the roof ramp.

High furnace pressure and theoretical air are beneficial to heat transfer, although in some cases a moderate excess of air cools the roof and so permits a higher rate of driving and an increased heat transfer to the hearth.

PART VI—SUMMARY OF RESULTS AND THEIR APPLICATION IN PRACTICE

By J. R. Hall and A. H. Leckie, Ph.D.

Synopsis

The extent to which the experimental results obtained on the small-scale furnace, operated by the British Iron and Steel Research Association at the works of the Shelton Iron, Steel and Coal Company, Ltd., have been applied in practice, is summarised. Arrangements for future investigations of open-hearth furnace combustion problems are briefly outlined.

Discussion

Mr. R. W. Evans (Steel Company of Wales, Ltd.) : We should emphasise that in this aspect of open-hearth furnace design the British technicians are actually leading the world ; there is no doubt about that at all, and it is due largely to Dr. Leckie and his enthusiasm and ideas that that situation has come about. It is true to say that the open-hearth furnace is almost approaching a static design, in that the objects are clearly defined of many of these researches. First of all, we want to keep the temperature of the flame as high as possible without doing extreme damage to the refractories. Secondly, in these designs we must always bear in mind that the furnace has to stand up, and we must try to preserve the refractories even if that has a serious effect on what otherwise would be a good design from the point of view of flame betterment.

Sir William Siemens put the open-hearth furnace into operation about eighty years ago. His invention was followed by a number of very revolutionary ideas, and people started putting the ports all over the place ; but they soon got tired of that, and about the year 1905 the open-hearth furnace began to settle down to what is more or less accepted, even to-day, as a basic design, with the exception of the single-uptake furnaces—that is, the double-uptake with driven fuels. In 1905 at Homestead, in the U.S.A., where they had a large number of 50-ton furnaces, they worked a short week of sixteen charges a week on American conditions of raw materials. Having got as far as that, the furnace has remained fairly static up to the time that Dr. Leckie began to throw doubts on the question of whether in fact it was in its best form.

This conception of flame temperature development is one which is extremely important, particularly with driven fuels. On producer gas we have a flame which sometimes spreads a little and is rather more liable to result in damage to the refractories, but with driven fuels we have a flame the direction of which we can reasonably control, and therefore a better chance of seeing exactly what the effect on the refractories is. While it is necessary to have a good mixing in the furnace port, it is also necessary for the best flame development to have high air pre-heats, and I am firmly convinced that on that line the one instrument which we must have very shortly is a recording suction pyrometer, which will enable us to see on furnaces whether actually we are getting the highest pre-heats of the air, which are absolutely essential, because high air pre-heats give us mixing to a very much greater extent ; we have far more energy in the particles of the gases.

Another matter of great importance is air infiltration. It is a pity to design a furnace on the very best lines and then find that you are not developing the flame temperatures that you thought you might get, because you have air infiltration. In that respect, modern plants are laid out so that there is plenty of room round the furnace, at the ends, underneath and above the stage, so that it is possible to insulate the furnace up to stage level and keep the insulation there and look after the furnace, and by that means we put the hot air just where we think that it should be.

On the question of air pre-heat, nowadays the life of the checkers of the furnace has been considerably prolonged, again particularly with driven fuels, owing to the fact that we are able to blow the checkers. Some of us use wider vertical apertures, which in no way detract from the air pre-heat but give a considerably longer checker life. It is true that a number of single-uptake furnaces work quite satisfactorily, but I think that perhaps a word of caution is necessary before we go too wholeheartedly in this direction. At the Steel Company of Wales we have 200-ton furnaces which I think Dr. Leckie would refer to as being of good old-fashioned design ; they have two uptakes and are worked on fuel oil. They have very large uptakes and the furnaces are sealed off to a very great extent. Although they do not have a single uptake they work at extremely low fuel consumptions, even compared with American practice, in spite of the fact that they work with very high metallurgical load.

Dr. J. H. Chesters (United Steel Companies, Ltd.) : We are only at the beginning of the road and, as has just been rightly said, some of the best furnaces working to-day look extraordinarily like the ones of fifty years ago at least. Even when we make all the changes that Dr. Leckie recommends, we shall still essentially be building the furnace which Siemens built. We have, on the other hand, an enormous advantage over Siemens or over anybody in the last twenty years in that we have a great deal of fundamental information available. We have all these curves, we have Parts I to VI of this work, we have our own work on flow patterns, we have Mr. Thring's work on mixing rates done in air, and we are in the unique position of having three or four laboratories capable of investigating any problem that anybody puts to them, whether it is done by air or water or an actual scale model of a furnace ; and also, with the co-operation which is now available, if any of these ideas shows real promise there is not going to be much difficulty in convincing the practical people that they should try it out. What I feel is desperately important at this stage is to define what it is that we are trying to get and how we might possibly get it. We are talking here about ways of improving efficiencies by 10 per cent and by 15 per cent, and that is very creditable and is a great help, but it seems to me that we are much more likely to get 20 per cent or 30 per cent if we set out to get 200 per cent or 300 per cent. That may sound foolish, but it is very much the tone of our own work, and many of the things about which I am talking are things which we are trying to do, though we are still in a very preliminary stage.

Mr. M. W. Thring (B.I.S.R.A.) : My main point of criticism is one which I have often discussed with Dr. Leckie, and that is that in his model work he finds out the effects of heat transfer but he does not explain them sufficiently. There are in fact probably three fundamental properties of flames with which we are concerned here : (i) the question of flame length, where it starts and where it finishes ; (ii) the question of vertical flame position, the angle downwards, how high up it is over the bath and how well it keeps down on the bath, and (iii) the heat transfer factors of emissivity and convection.

Dr. Leckie's model is not good in similarity on the emissivity question, because the scaling down upsets emissivity similarity, so that we can leave that out ; but the question arises of whether the effects which he shows in his Fig. 8 are mainly due to changing the angle of the flame or to changing where combustion finishes. I think that they are mainly due to where combustion finishes, and that it is mainly a question of flame length, but it may be a question of flame angle as well. If it is flame length, he can determine that, of course, by putting water-cooled gas-sampling probes in with different ports and seeing where the combustion finishes, or by using the cold air models or water models ; but, when he has determined it, we then have the fundamental question of whether we should make our flame shorter or not. Dr. Chesters and I, some years ago, drew as the main conclusion that the producer-gas flames at that time were too long, and I think on the whole that that generally applies. It is possible to make the flame too short in an open-hearth furnace. But there is an optimum flame length, and I think that in general flames are too long. That is one of the main functions of the air model work which Mr. Newby is doing, to show how to control the flame length. I should like to ask Dr. Leckie for some further explanation. He gets these tremendous effects with heat transfer ; are they due to flame length, or can they be ascribed to flame angle as well ?

My other point is a criticism of the steel industry rather than of B.I.S.R.A. In my view it is high time, as a result of Dr. Leckie's work, that somebody for the first time did a proper experiment on an open-hearth furnace. In my opinion nobody has ever done a proper experiment on an open-hearth furnace as far as the flames are concerned, and it is time that they did. We are now building up knowledge on how to adjust the flame length and the flame angle and control all these flame properties, but we have never done an experiment as a result of which we could say that when we change the flame length the effect on output, refractories consumption and fuel economy is exactly so much. I think that the most important thing for Dr. Leckie's

team to do now is to persuade some firm to allow them to have a say in the rebuilding programme of one furnace and do a proper experimental programme on one furnace.

Mr. M. P. Newby (B.I.S.R.A.): I am very interested in these papers, because they deal with work done on models of furnaces at high temperatures, and my own field of work is also models of furnaces, but operated at low temperatures. Very roughly, it may be said that in the problem of heat transfer there are two general problems: one is where the heat is coming from and the other where it is going to. The work of which we have heard this morning has been an attempt, and a very successful one, to determine from a model where some of the heat released in a furnace is going to. I submit that cold models should always be built in collaboration with this class of work, because they are very good in showing easily where the heat should be coming from. In particular, a cold model gives a very quick and easy method of predicting where a flame should be inside the furnace and giving an idea of the size of it and an idea of the rate of combustion which is going on. Mr. Thring spoke about flame length, which is the same thing. Flame length depends on the rate of combustion along the flame and the quicker the combustion the shorter the flame. A cold model can show that very clearly. When listening to the papers, I felt that perhaps there had been not enough collaboration between those of us who build cold models and Dr. Leckie and his collaborators, who build hot models, but the connection between the hot and the cold is still largely inferential. We have no exact measurements between the two. I suggest that in future work which is done on similar lines there should be closer co-operation between the people working in these two fields, so that we can get a clearer interpretation of the results in terms of the actual flame conditions.

Dr. D. F. Marshall (Park Gate Iron and Steel Company, Ltd.): I think that the papers and the discussion have centred on two items in particular on which I should like to comment. The first is fuel/air ratio. We all know from experience that in the case of a mill furnace, for example, with a very tight system, the very first control that one would put on would be of the fuel/air ratio, and the benefits to be obtained from that are undoubtedly very material. Then we come to the open-hearth furnace and the moment we add to that system checkers and a lengthy flue system the picture becomes very much more doubtful. If we look at American practice, it is highly significant to me that the American furnaces started originally with fuel/air ratio as the No. 1 control, but in more than 90 per cent of the cases that has now been dispensed with, and on these American plants thousands of pounds' worth of equipment is standing idle because that control has not fulfilled the purpose which the Americans originally thought that it would. If you want to obtain the best advantage of fuel/air ratio from an open-hearth furnace in particular, I think that you must have with it furnace pressure control, because without that I do not think that fuel/air ratio on the open-hearth furnace has much chance of being of material benefit.

On the subject of air infiltration, I think that the whole question is a challenge to furnace designers, and once more I should like to refer to America. Modern American plants and the South Wales plants, do make accessible all the vulnerable parts of the furnace. In many plants in this country it is not possible to reach the vital parts of the furnace. If I were designing a new plant one of the first steps that I should take would be to make the furnace accessible, so as to keep the air infiltration down to a minimum value.

Mr. J. E. Pluck (Steel Peech and Tozer): The work of Mr. Allen and Dr. Leckie is absolutely invaluable to build on for the future, but their model shows a furnace with a flat hearth, and I am wondering whether it would be possible to simulate an actual furnace by putting in water tanks with a hump in the middle, which would represent the average shape of scrap when partly melted. I feel sure that such a condition is a very important part of the furnace programme. You are melting half the time and refining half the time. The melting condition is important, and is where the maximum amount of heat must be put into the bath. Moreover, the scrap would very materially change the flow patterns, and heat transfer would, I feel, be very different from that shown in the paper.

(To be continued)

Standard Class "3" Tank Engine

WE reproduce below a photograph of the first of a new standard class "3" 2–6–2 tank engine for British Railways, which was built at the Swindon works in the Western Region. This locomotive is designed to replace various tender and tank engines of similar power classification now becoming obsolete. It has a tractive effort of 21,490 lb, as compared with the 25,100 lb of the standard class "4" tank engine described in our issue of August 3, 1951.

Of the twenty locomotives of the class "3" 2–6–2 to be built in 1952, the first ten have been allocated to the Western Region and the rest to the Southern Region. They have been designed and built under the direction of Mr. R. A. Riddles, Member for Mechanical and Electrical Engineering, Railway Executive. The parent office for the design of the new engines was Swindon, whilst certain sections were designed at Brighton, Derby and Doncaster.

Like the class "4," both tender and tank types, the class "3" has almost universal availability over main and secondary lines throughout Britain. The leading dimensions are as follows:—

Cylinders, diameter and stroke	17½in by 26in
Wheels, coupled, diameter	5ft 3in
Wheels, pony trucks, diameter	3ft
Wheel base, coupled	15ft 4in
Wheel base, total	32ft 7in
Heating surface:	
Tubes	932·9 sq ft
Firebox	118·4 sq ft
Total evaporative	1051·3 sq ft
Superheater	190 sq ft
Grate area	20·35 sq ft
Boiler pressure	200 lb per sq in
Tractive effort	21,490 lb
Adhesion factor	5·08
Weight of engine in working order ...	74 tons 1 cwt

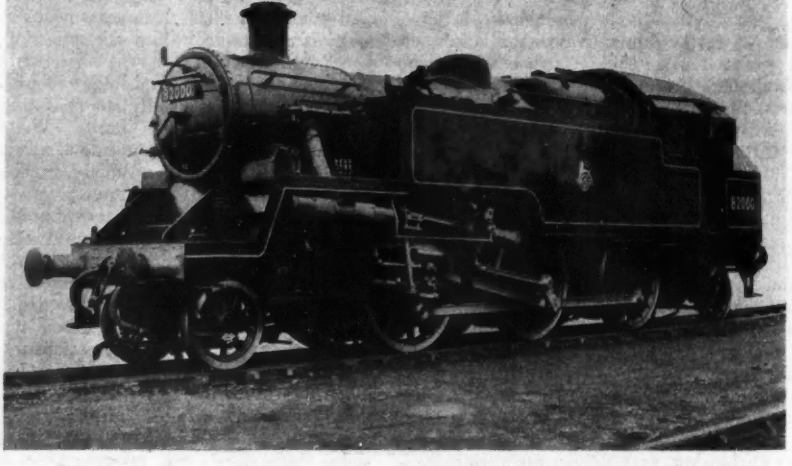
The boiler follows closely the design of the ex-G.W. Standard "2" used on the "5100," "6100," "8100" and "5600" classes, and the steel and copper flanged plates for the firebox are common to both designs, but the barrel is 5 $\frac{15}{16}$in shorter. This barrel has two rings, the second of which is tapered, the outside diameter being 4ft 5in at the front and 5ft 0$\frac{1}{8}$in at the firebox end. Eighteen large flue tubes, 5$\frac{1}{8}$in. diameter outside, are fitted, together with 145 small tubes, 1$\frac{3}{4}$in diameter outside, the length between tube plates being 10ft 10$\frac{1}{4}$in.

The Belpaire firebox is 7ft long at the bottom, with an outside width of 4ft, and the steel and copper wrapper plates of the outer and inner fireboxes respectively are both $\frac{7}{16}$in thick. Both throat and back plates are vertical and the copper tube plate is $\frac{5}{8}$in thick. All the firebox water space stays are made of Monel metal, fitted with steel nuts inside the firebox, while the roof, longitudinal and transverse stays are of steel.

A rocking grate and self-emptying ashpan are fitted, as many details as possible and also the controls being similar to those on other standard locomotives. The boiler mountings, regulator, clack valves and manifold are similar in design to those used on classes "4" and "5" standard locomotives; and the smokebox self-cleaning arrangement also follows closely these two classes. A blast pipe with a plain circular cap, 4$\frac{1}{2}$in diameter, contains the four nozzles of the Cardew blower.

The engine frame, as on existing standard locomotives, is adequately stayed both horizontally and vertically, whilst boiler securing and springing arrangements and the method of staying axlebox guides are also rather similar to those obtaining on the other classes. The coupled wheel base is 15ft 4in, as on the class "4" tank engine, and the driving wheel divides it in the same proportion on both classes.

Other similar design features include the axleboxes, axlebox guides, method of lubrication and cylinder cock and sanding arrangements. The cab layout follows as far as possible



STANDARD 2-6-2 TANK ENGINE

the design laid down as standard for tender engines.

The two cast steel cylinders, which carry cast iron liners, are placed outside the frames. Piston valves of 10in nominal diameter are operated by Walschaerts valve gear, giving a full-gear travel of 6$\frac{27}{32}$in, corresponding to a cut-off of 75 per cent with a steam lap of 1$\frac{1}{8}$in and lead of $\frac{1}{4}$in. The motion has more in common with the class "4" tank engine than with other B.R. standard locomotives as both have the two-bar "crocodile" form of crosshead, and the same method of reversing using a sliding block in a slotted extension to the radius rod behind the motion plate.

The leading pony truck is similar in all respects to that fitted to the class "4" tank engine, the side play being controlled mainly by double helical springs, while the trailing truck is of the swing link type. The method of transmitting the load to the axleboxes and the side play control retarding gear are the same for both pony trucks.

The tanks and bunker are of welded construction throughout, the former being carried at the leading end on the outside slide bar bracket and at the trailing end on a frame bracket. Unlike the class "4" tank engine, no water is carried under the bunker. The tanks have a water capacity of 1500 gallons and the bunker a coal capacity of 3 tons.

A Coal Lorry with a Conveyor Belt Discharge Unit

THERE are many establishments using solid fuel in which the bunkers and stock-piles are arranged in places to which access is difficult for the normal design of tipping lorry. In order to overcome this difficulty and speed the work of handling bulk fuel in such cases a special lorry has been developed and built by Charrold, Ltd., 40, Trinity Square, London, E.C.3. This lorry can be loaded by bulk mechanical means and has built-in unloading equipment. Its use eliminates the tedious, expensive, manual labour involved in filling and carrying sacks when delivering to places difficult of access.

The lorry is to be seen in operation in the photograph we reproduce. It incorporates an adjustable conveyor unit, with which it can stack fuel into piles up to 7ft 6in high and trim it over an appreciable area; deliver fuel through small hatchways or cellar windows and project it forwards some distance; and deliver over walls into bunkers. Coal or coke up to 4in screen can be handled at a rate of up to $\frac{3}{4}$ ton per minute.

The lorry has a fabricated metal hopper some 12ft long and 6ft 9in wide, designed to carry 5$\frac{1}{2}$ tons of coal. The hopper sides can be fitted with metal extensions to increase its capacity for lighter fuels, such as coke, or allow a further ton of coal to be carried. The lower sides of the hopper slope inwards and are fitted with a series of flap gates operated by levers at the rear of the vehicle. These gates can be opened in turn to deliver the fuel at a controlled rate on to a scraper belt conveyor running the full length of the body floor. The conveyor is driven through chains, a clutch and a reduction gear unit from the power take-off shaft of the lorry engine. It discharges the fuel out of the rear of the body.

LORRY DISCHARGING TO STOCK PILE

For discharging purposes a second belt conveyor unit, some 13ft 6in long and called a "toter," is used. This "toter" unit is a light fabricated pressed steel beam, which incorporates a belt conveyor driven by a hydraulic motor, and when the lorry is travelling it is carried on a cradle along one side of the hopper body. When the lorry reaches its unloading point the "toter" conveyor is pulled out and supported from a small jib with a self-sustaining hoist mounted at the rear of the hopper, as shown in the illustration.

The inner end of the "toter" is attached to a bracket under the discharge chute, into which the scraper conveyor deposits the fuel. The hydraulic motor of the "toter" conveyor is then coupled by flexible pipes to a pump unit on the lorry chassis. This pump unit is also driven by the power take-off shaft through a chain and sprockets. Hydraulic fluid is supplied through a two-way valve controlled by a lever at the side of the main conveyor clutch lever at the rear of the vehicle.

When the "toter" has been adjusted to suit the bunker or point of delivery the engine is accelerated by operation of a lever at the rear of the chassis. One of the hopper gates is then opened and on the main scraper conveyor clutch drive being engaged fuel is delivered at a controlled rate into the chute leading down to the "toter." On the valve of the hydraulic drive unit then being moved over the "toter" belt comes into operation to deliver the fuel. As unloading proceeds successive gates are opened until the hopper is empty.

The mounting of the "toter" and the use of flexible pipes for coupling it to the hydraulic system allow it to be traversed over an angle of 180 deg. and it can be elevated during working by means of the jib crane to raise the delivery end up to a height of 7ft 6in. A simple locking device secures the jib in any required position.

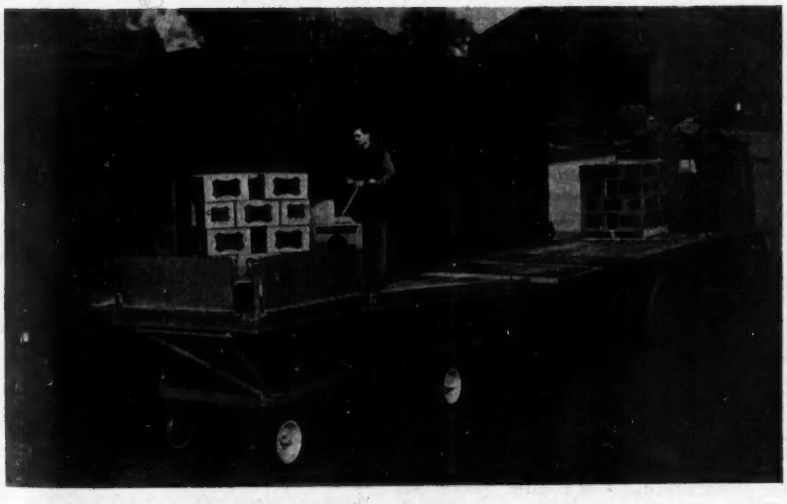
The makers state that one man can discharge a full load from the lorry in from ten to twelve minutes to which about five minutes must be added for manipulation. One of these vehicles in service, it is stated, can deliver between 4000 tons and 6000 tons of fuel a year.

A Mobile Loading Platform

A MOBILE loading platform has been introduced by Lansing-Bagnall, Ltd., of Basingstoke, to facilitate the loading and unloading of railway goods wagons directly from and to road vehicles by means of power pallet trucks. This new unit is portable and obviates necessity for loading bays when transferring loads between vehicles.

As can be seen from the photograph we reproduce the unit consists of a simple four-wheeled trailer on which there are two platforms hinged together at an intermediate point. These platforms are adjustable for height and can be raised or lowered through mechanical screw jacks and a linkage system. One platform section—that used at the rail wagon end—remains in a horizontal position at all levels. It has a vertical movement of from 3ft 9in to 5ft 3in above ground level, and is 6ft long by 6ft wide. The other platform section—which connects the horizontal platform to the road vehicle—is 10ft long and 6ft wide. Its outer end has a vertical movement of 3ft to 4ft above ground level, and through this height adjustment the platform is used to form a sloping ramp between the road vehicle and the horizontal platform set at the rail wagon floor level.

The two sides and end of the horizontal



MOBILE LOADING PLATFORM IN USE

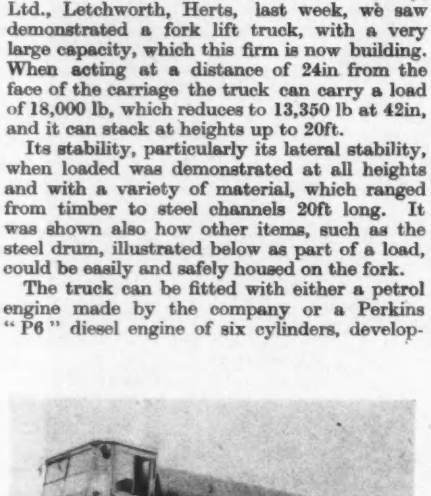
platform section and the outer end of the sloping platform are fitted with hinged flaps which are let down to act as bridge plates when the unit is in use. When the loading platform is in position and its sections adjusted between the rail wagon and the lorry, loaded pallets can be freely moved between the vehicles by means of a small pallet truck as shown in the illustration.

Heavy Duty Fork Lift Truck

At the works of Shelvoke and Drewry, Ltd., Letchworth, Herts, last week, we saw demonstrated a fork lift truck, with a very large capacity, which this firm is now building. When acting at a distance of 24in from the face of the carriage the truck can carry a load of 18,000 lb, which reduces to 13,350 lb at 42in, and it can stack at heights up to 20ft.

Its stability, particularly its lateral stability, when loaded was demonstrated at all heights and with a variety of material, which ranged from timber to steel channels 20ft long. It was shown also how other items, such as the steel drum, illustrated below as part of a load, could be easily and safely housed on the fork.

The truck can be fitted with either a petrol engine made by the company or a Perkins "P6" diesel engine of six cylinders, develop-



HEAVY DUTY FORK LIFT TRUCK

ing 70 b.h.p. at 2200 r.p.m. The petrol engine has four cylinders 98mm by 120mm stroke, with side valves and develops 70 b.h.p. at 2800 r.p.m.

To avoid angularity in the transmission the engine is inclined upon its three-point mounting and drives through a 14in dia. dry-plate Borg and Beck clutch to the gear box. This unit provides four speeds, forward and backwards, the controls being arranged so that after selecting the desired ratio with the main lever a second lever is used to determine the direction. A hypoid drive is employed with fully floating shafts and taper roller bearings at the wheel and differential. The steering stub-axle is mounted on a central trunnion bearing providing the vehicle with a three-point suspension, and steering is assisted by a hydraulic booster. Steering reverts to direct mechanical action when the engine is stopped.

Frame and Hoist

The frame is a heavily braced, welded structure, carrying a 4 ton counter weight at the rear. The mast is constructed of deep-section channels heavily cross-braced, which telescope on heavy duty roller bearings. A low pressure hydraulic ram 6¾in in dia. of the displacement type, incorporates at its ends self-aligning ball and socket mountings. Twin multiplate hoist chains are fitted. Between the mast and the rear superstructure is interposed a horizontal double-acting ram 5in dia., which can tilt and secure the mast in any position from 3 deg. forward of the vertical to 10 deg. aft. The carriage and its forks are also of welded construction and likewise run on heavy duty roller bearings. In order to facilitate loading and stacking the truck is afforded another freedom by the incorporation of an hydraulically controlled side-shift, which enables the forks to move laterally 5in to either side of the normal position. The forks themselves can be adjusted manually between centres of 36in to 59in. Automatic control of the lowering speed is provided and the lift speed of the carriage is 35ft per minute.

Two rotary vane pumps are mounted together and are driven through gears from the engine; the smallest is designed to give full power at all engine speeds for the purpose of feeding the steering booster. The valve box of the main hydraulic system is mounted directly on the oil reservoir and the control levers are closely grouped. As the levers are spring-loaded the pump is automatically unloaded and a sensitive control of all movements of the mast and carriage is obtained.

The truck is fitted with standard interchangeable disc wheels, single at the rear and twin wheels at the front. It has an overall width of 85½in, a length to the face of the carriage of 156in, a wheelbase of 82in, and its weight is approximately 18,000 lb. The turning radius is 14ft 3in but it can negotiate a right-angled passage 12ft 6in wide and is capable of a road speed of 22 m.p.h.

The Folsom Power Station in California

A contract for the construction of a power station at Folsom dam, on the American River, 20 miles east of Sacramento, California, has been awarded to the Guy F. Atkinson Company, of San Francisco. The 340ft high, 10,230ft long Folsom dam is a concrete and earth-fill structure, which will store run-off from the Donner Pass area, and is being constructed by the U.S. Army Corps of Engineers for later operation by the Bureau of Reclamation as an integrated flood-control feature of the comprehensive Central Valley water conservation project. The 162MW power plant is being installed and operated by the Bureau of Reclamation, which will market the hydro-electric energy output. The contract calls for the construction of a semi-outdoor station, mostly underground, with a 96ft by 228ft reinforced concrete building, the installation of a 250-ton outdoor travelling crane, and the installation of the embedded parts of three 74,000 h.p. hydraulic turbines. When completed the station will contain three hydro-electric generators of 54MW capacity each, and the combined annual output of the plant is estimated at 490,000,000kWh. To date, eleven contracts preliminary to the actual construction of the station, for equipment and other power facilities, have been awarded by the Bureau. The three 74,000 h.p. turbines were ordered from the Newport News Shipbuilding and Drydock Company, on a bid of 1,629,625 dollars; the 54MW generators from the Westinghouse Electric Corporation, for 2,550,185 dollars, and transformers from the General Electric Company (U.S.A.), on a bid of 577,044 dollars. Last month, American manufacturers were unable to meet the official time schedule and financial arrangements for furnishing an auto-transformer for the Folsom power station, and the contract was awarded to the English Electric Company, of Stafford, on a bid of 247,696 dollars.

A Liquid Plastic Coating.—A new paint made by Solignum, Ltd., and known as "Permacote" satin emulsion paint, is based on non-oxidising oil-free plastic resin dispersed in water. On application the water evaporates leaving a continuous layer of pigmented plastic resin.

French Engineering News

(By our French Correspondent)

The Croix-Rousse road tunnel running under the hills of the same name in the Lyons area was opened last month by the Prime Minister. The new tunnel will save road traffic a long detour. It will permit the passage of between 3000 and 4000 vehicles per hour. The tunnel is 1752m long.

The ventilation system is of particular interest. It embodies four ducts, each some 4m in diameter, so that the air inside the tunnel is changed every three minutes. The lighting is arranged to avoid motorists plunging into dim light from the bright light outside, and a cluster of powerful electric lights has been installed at the entrance of the tunnel. The intensity of the light diminishes towards the interior of the tunnel and increases at the other end. A new bridge across the Rhone has also been built as part of the project and will ease congestion in the city of Lyons.

* * *

A new telephone cable between Dijon and Nancy has just come into operation. It is the most modern of its kind in France and comprises four coaxial tubes with a capacity of 2000 circuits. The cable was made in France and its construction took twelve months.

* * *

Monsieur Antoine Pinay told members of the National Assembly that France had contracted to help build the Mont Blanc tunnel. He said that if France now withdrew, as some deputies appeared to wish, a tunnel would be built beneath the Grand St. Bernard, and France would be left out. He said that work on the Mont Blanc tunnel would not begin before the end of 1952. The tunnel would not, therefore, be open by 1956, as was hoped. The cost of construction would amount to approximately 80 million Swiss francs, of which 28 million would come from private sources. The rest would be contributed by France, Italy and two Swiss cantons.

The French end of the tunnel will be situated at Chamonix at an altitude of 1200m. A diversion road leading to the tunnel will start at Pelerins and will run for about 5km. The tunnel will emerge on the Italian side at Entreves at an altitude of about 1380m. A road will be built to connect the tunnel with the Aosta highway.

The length of the tunnel will be 11·7km. It will be 4·35m high and 8m wide. The road inside the tunnel will be 7m wide. Inside the tunnel the incline will be about 1 in 50, but at the approaches it will be 1 in 25. The ventilation system will incorporate the best modern practice.

* * *

Over the next five years it is planned to spend £150 million in France on road improvements. The amount is less than the figure asked for by the engineering services of the Public Works Ministry. Eleven national roads will be improved, under the plan, by the construction of by-passes. Four motorways will be built, as well as five special tourist roads, and 126 level crossings will be eliminated. Work on these projects is about to start and is scheduled to be completed in 1957.

* * *

The Strasbourg coking plant is to be re-equipped and modernised. This plant will produce about 200,000 cubic metres of gas daily when the new installations are completed.

Coal handling will be modified. It is expected that the handling rate will be about 150 tons per hour from barges, using two 87m long travelling cranes, each with a capacity of 75 tons per hour, and equipped with 2-ton skips. The installation will also include a preliminary crushing installation and a magnetic separator; four coal silos, each holding 500 tons of coal, and three hammer crushers capable of dealing with 75 tons per hour. The plant will have three groups of Koppers ovens and two primary water-tube condensers with a cooling capacity of 200,000 cubic metres of gas per twenty-four hours. The plant will also have a 400,000 cubic metres capacity ammoniac washer and a dry purifying plant will have a capacity of 180,000 cubic metres per twenty-four hours.

Industrial and Labour Notes

Wages and Prices

A special meeting of the National Joint Advisory Council—which consists of representatives of the British Employers' Confederation, the Trades Union Congress and the nationalised industries—was held in London on Thursday of last week to hear a statement on the economic situation by the Chancellor of the Exchequer, Mr. R. A. Butler. The Chancellor said that, in the first quarter of this year, the gap between visible exports and visible imports was reduced to £211,000,000 from the average quarterly rate of £302,000,000, which prevailed in 1951. The country's gold reserves at the end of March were not more than 1,700,000,000 dollars—which was just over 40 per cent of their June, 1951, level—and were inadequate for the job they had to do. On the internal side, the Chancellor continued, industrial production in the first quarter of this year was little, if at all, above the level of the same period last year. It reflected the difficulties of the steel industry, the consequential check to the growth of engineering production, and the fall in demand for textile products. In the coal mines—on which the country's whole capacity for expanding production depended—employment had continued to rise. But coal production, Mr. Butler pointed out, was not yet rising commensurately, and a substantial rise in exports would do more than anything else to put the country on its feet. It was clearly of paramount importance that both production and productivity should be increased.

The Chancellor then dealt at some length with the subject of inflation, referring in particular to the wage-price spiral. He said that for about two years now prices and wages had been chasing each other in a way that gave cause for much anxiety. It was necessary, therefore, to take a serious view of the indications during the last few weeks that the wage-price spiral might be resumed because of renewed pressure for higher wages. Summing up his comments on wages and prices the Chancellor said that the Government would do everything in its power to stop prices rising, but prices could not be kept down if wages and salaries kept on rising unreasonably. It would be foreign to this country's ideas and practices to attempt to curb wages and salaries by central direction and, therefore, the Chancellor claimed, responsibility on both sides of industry took on a new form. That was to establish conditions under which the national wage bill would advance in step with national production, but not outstrip it, without destroying the flexibility of relative wages. The Government believed, the Chancellor added, that the first requirement was that industry should recognise the urgency and gravity of the problem and determine that it must be solved.

Exports to the Dollar Areas

Speaking at a meeting of presidents and chairmen of trade associations, held in London last week, Sir William Rootes, chairman of the Dollar Exports Council, stressed the importance of the Caribbean and "dollar account" markets. He mentioned in particular the territories in the "important quadrilateral lying between the equator and Latitude 32 deg. North and Longitude 120 and 56 deg. West, from Mexico and Venezuela to the Bermudas and British Guiana."

Sir William suggested that this country had to some extent neglected those markets in the post-war years, though the admirable pioneer work of many firms and individuals must not, he said, be overlooked. But as a result of that comparative neglect, the attraction of the American mainland had proved strong even in the British Colonial possessions. This, Sir William continued, had meant two things: one, that dollars were being spent in the British possessions in the area, which could be saved by the supply of United Kingdom goods, and the other, that while each country in the area should be regarded as a separate problem, generally speaking they should all be treated as similar to the United States market itself. Sir William warned the meeting that "time was not on our side." Foreign competition, he said, from such countries as Germany, Italy, Holland, Belgium and Japan, was already strong and was daily growing stronger, sponsored in many cases by the Governments concerned.

Iron and Steel Production

The output of steel ingots and castings during April averaged 305,100 tons a week and was thus at an annual rate of 15,866,000 tons, compared with an annual rate of 16,648,000 tons in March. It should be borne in mind, however, that this year the Easter holiday fell in April. Last year it was in March, but steel production then was at an annual rate of 16,546,000 tons. Pig iron output in April this year averaged 201,400 tons a week, which represents an annual production rate of 10,472,000 tons, compared with a rate of 10,490,000 tons in March and a rate of 9,280,000 tons in April last year.

Production Costs and Exports

In the latest issue of *Bulletin for Industry*, which is a review of the economic situation prepared by the Treasury, reference is made to the serious competition which has now returned to foreign markets for most kinds of manufactures. Even in the case of capital goods, the world demand for which is still very heavy, it is stated that keen prices may often be necessary if export earnings are to be increased, particularly where foreign firms can offer shorter delivery dates and longer credit than firms in this country.

By March of this year, the *Bulletin* says, British export prices for metals and engineering products together were just under 30 per cent higher than in September, 1949 (the time of devaluation). Future prices of British exports, as of goods for the home market, it is pointed out, depend largely on present movements in costs of production. The steep increase in import costs, after the outbreak of the Korean war, set off the rise in prices of manufactured goods in 1951. The wholesale prices index for basic materials rose by 75 per cent from June, 1950, to its peak in March, 1951, but by March this year it had fallen about two-thirds of the way back. Prices of copper and other non-ferrous metals—apart from tin—though still high relative to June, 1950, have been fairly stable since the third quarter of last year. But, the *Bulletin* explains, even after allowing time for changes in raw material costs to work through to the price of finished goods, it is unlikely that they will lead to any general increase in export prices in the next few months.

Since the end of 1950, however, there has been a steady upward movement in labour costs as the rise in retail prices of some manufactured goods (begun by the rise in import costs) led to successful claims for higher wages which outstripped any increase in productivity. Increases in labour costs and import prices in 1951 were also the main cause of the recent rise in prices of transport and of home-produced materials such as iron and steel, cement and fuel. Higher labour costs in industry, the *Bulletin* adds, would give a new and dangerous upward thrust to export prices.

Industrial Production and Steel Supplies

According to a report prepared by the Information Division of the Treasury, production last year in the engineering, shipbuilding and electrical goods industries was 7 per cent higher than in 1950. The rate of increase, however, fell from 11 per cent in the first four months to 4 per cent in the last four months of the year. In January and February of this year, output was still rising, the increase over a year earlier being 4 per cent. The main limiting factor, of course, is the supply of steel.

In manufacturing and in building, the report notes, steel shortage continues to hinder production. From behind the steel shortage another difficulty is beginning to emerge. It is concerned with coke supplies to enable more pig iron to be made from increased supplies of iron ore, both from home sources and abroad, in replacement of dwindling scrap imports. There are hopes that a progressive improvement throughout this year will raise steel production above the 1951 figure of 15,600,000 tons, but this, in turn, depends on a considerable increase in iron ore and hard coke supplies. Prospects for imports of rich iron ore have improved, but lack of coke suitable for blast-furnaces may hold back pig iron production.

Human Relationships in Industry

The College of Technology, Birmingham, has announced its intention of appointing a senior lecturer in its Department of Industrial Administration to conduct study of the problems of human relationships in industry and to develop the capacity of students of industrial management to work effectively with people. The objective of the Department, it is stated, is to promote and extend teaching in the field of human relations in order to give greater appreciation of the human aspects of industrial management. This, it is claimed, will lead to the establishment of a "body of knowledge," which will be of personal aid to those training for supervision and management, and also to those holding man-management responsibilities.

Europe's Coal Supply Prospects

The coal trade sub-committee of the United Nations Economic Commission for Europe has recently held a meeting during which solid fuel supply prospects for the third quarter of this year were examined. It is expected that the coke shortage will remain at about the same level as that of the current quarter—that is, about 1,200,000 tons—including requirements for restocking purposes. The declared coal requirements of the various importing countries have decreased by about 1,000,000 tons compared with those of the second quarter, and, in addition, a small increase in European coal export availabilities was indicated. The theoretical deficit in European coal supplies, which has amounted to about 7,000,000 tons in the current quarter, is thus expected to fall to about 5,800,000 tons in the coming quarter. This deficit, the sub-committee has announced, has been based on stated requirements and may be further reduced when availabilities are set against minimum requirements. It is added, however, that the deficit does not take into account possibilities of imports from the U.S.A., which might help especially to cover coking coal requirements.

Coal Output

Total coal production in Great Britain last week amounted to 4,508,700 tons. It included 4,250,000 tons from the deep mines and 258,700 tons from opencast workings. Last week's total output showed an improvement of over 260,000 tons compared with the preceding week, when holidays in Scotland accounted for a loss of about 176,000 tons. In the first twenty completed weeks of this year, to May 17th, coal production totalled 88,607,400 tons, or nearly 2,000,000 tons more than in the comparable period of 1951. Coal imports this year have amounted to 318,000 tons against 1,085,400 tons in the first five months of last year. In the week ended May 10th, there were 715,800 wage earners on colliery books, of whom 291,600 were working at the face, output per manshift at the face amounting to 3·19 tons. Total coal consumption—including exports and bunkers—in the same week was 4,178,000 tons, and distributed stocks on May 10th amounted to 13,809,000 tons, compared with 10,174,000 tons a year earlier.

Notes and Memoranda

Air and Water

ORIENT LINER.—The liner "Orsova," which Vickers-Armstrongs, Ltd., is building for the Orient Line, is to have one funnel and no masts; the funnel will be fitted to carry the wireless and other essential rigging.

FOREIGN HOLDERS OF PILOT'S LICENCES.—The Ministry of Civil Aviation has recently reintroduced last year's concession whereby foreign pilots may within the privileges of their licences fly private aircraft in the United Kingdom without formal M.C.A. validation of their licences.

DOXFORD OIL ENGINES.—John Lewis and Sons, Ltd., is to build Doxford engines under licence and the first engine developing 1100 b.h.p. at 145 r.p.m. has completed preliminary tests. The company intend to build engines of this design ranging from 600 b.h.p. to 2000 b.h.p., and will later extend the range to between 400 b.h.p. to 3000 b.h.p.

BAUXITE ORE CARRIER.—The Bauxite ore carrier S.S. "Schmedeman," which was launched last week from the Barrow shipyard of Vickers-Armstrongs, Ltd., for Reynolds Jamaica Mines, Ltd., will be fitted with self-unloading equipment. Consisting of conveyor belts and a stern boom, the gear will enable the ship to discharge ore at the rate of 1500 tons per hour into railway wagons.

AIR TRAFFIC STATISTICS.—Passenger traffic on United Kingdom airlines continued to increase in February. The corporations and their associates flew 67 million passenger-miles. International traffic accounted for 64 million passenger-miles, a 15 per cent increase over February, 1951, while internal traffic was 24 per cent higher. B.O.A.C. increased their total revenue traffic by 13 per cent to 8½ million short ton-miles, and the overall revenue load factor reached 64·6 per cent, compared with 61·5 per cent in February, 1951. More than 50,000 passengers and 1000 short tons of freight, increases of 17 per cent and 35 per cent respectively, were carried by B.E.A.

MAIDEN CRUISE.—The motor launch "Queen Elizabeth," of Thames Launches, Ltd., made her maiden cruise since her conversion, on the Thames on May 15th. The launch, which can carry 375 passengers, has a length of 110ft by 16ft 6in beam, is driven now by a Gardner diesel engine of 150 h.p. at a speed of 10 knots. The interior of the vessel has been redesigned and part of the reconditioning work has included the fitting of an aluminium alloy deckhouse and permanent awning. The deckhouse is of considerable technical interest, since the aluminium alloys have been welded by the self-adjusting arc process which is known as "Aircomatic" in America and will be called the "Argonaut" process in this country, when it is marketed by the British Oxygen Company, Ltd.

BRITISH SURFACE WATER RESOURCES.—Detailed information concerning British rivers is contained in "The Surface Water Year Book of Great Britain, 1937–45," which has just been published for the Ministry of Housing and Local Government and the Scottish Office. It presents statistical records of the flows of a number of British rivers, together with related rainfalls, for the eight-year period ended in September, 1945, and is a successor to two pre-war publications, which dealt with the two-year period ended September, 1937. The majority of the gauging stations with which it deals are new to this series of year books and the varied character of the rivers studied (such as the Northamptonshire Nene and the Welsh Wye, which are typical of two different kinds of river), and the wide area of the country covered, will make this book a work of reference for engineers, hydrologists and geographers. The "Surface Water Year Book of Great Britain, 1937–45," is published by Her Majesty's Stationery Office, price 17s. 6d.

Miscellanea

USE OF GERMAN TRADE MARKS.—The Board of Trade is considering a number of questions relating to trade marks which were on the Register on September 3, 1939, in the names of German persons or concerns, living or carrying on business in Germany. Persons or concerns in the United Kingdom claiming to have a continuing interest in such trade marks, arising out of their use since September 3, 1939, in connection with goods manufactured in the United Kingdom, are invited to communicate with the Registrar of Trade Marks, stating the numbers (with short descriptions) of the German registered trade marks they desire to continue to use; the extent of their interests in those marks and the source of those interests; whether at September 3, 1939, there existed any contract or agreement between them and the German registered proprietors relating to the use of those marks; whether after September 3, 1939, they exercised registered user rights in those marks, and, if so, for what period; what goods have been or are being manufactured under those marks, and the periods during which the goods were produced. All communications arising on this subject should be addressed to the Registrar of Trade Marks (German Marks), Patent Office, 25, Southampton Buildings, London, W.C.2.

DEMOLITION AT THE SOUTH BANK SITE.—On May 13th last, the Minister of Works, Mr. Eccles, was presented with the commemorative plaque of the Skylon, which is now being demolished, together with the Dome of Discovery and several other major exhibition buildings at the South Bank exhibition site, by George Cohen, Sons and Co., Ltd. It is understood that the cost of re-erection of the Dome and the Skylon would almost certainly have been uneconomic, and the materials from the demolition will be sold as scrap. The Dome and the other buildings will be dismantled by the middle of September.

STRUCTURAL STEEL DESIGN.—The British Constructional Steelwork Association, Artillery House, Artillery Row, London, S.W.1, has now issued its technical brochure No. 4, entitled "Examples of Structural Steel Design to Conform with the Requirements of British Standard 449 : 1948, Part III." Examples are given in this publication of the design of stanchion bases—two stanchions each with single rolled steel joists and one stanchion with two channels battened. A design is also given of a single-angle rafter for a roof truss, and tables are given of safe loads of bolts in tension and of bending stress coefficients for angles used as simply supported beams.

REPAIR WORK BY POST OFFICE FACTORIES.—The G.P.O. has stated recently that at its factories in London, Birmingham and Edinburgh the repair of apparatus comprises more than 70 per cent of the total output. The replacement value of apparatus repaired exceeds £3,000,000 annually. The total number of classes of apparatus and equipment repaired in a year is approximately 2000. Items dealt with include fire protection equipment, clocks, stop watches, moving coil and radio equipment, measuring and testing equipment and unit assemblies of many kinds. There is also a regular monthly output of components, e.g., jacks, indicators, relays and coils, to enable the replacement of such articles on the site.

SOCIETE FRANCAISE DE METALLURGIE.—The Société Française de Métallurgie is to hold its autumn meeting in Paris from October 20th to 25th, at the Maison de la Chimie, 28 bis rue St. Dominique. The two main subjects to be discussed are "Faults and Fractures Observed in Metals During Service" and "Methods of Effecting Economies in Metals in Short Supply." A few communications on other subjects of particular interest will be allowed at some of the sessions. The programme will include communications by metallurgists from many European countries and from the U.S.A. A number of visits, including one to the new laboratories of the Institut de Recherches de la Sidérurgie, at Saint-Germain-on-Laye, will also be arranged. Other visits and a banquet will be held during the week. British metallurgists will be most welcome at this meeting and those interested are asked to apply for further details to Société Française de Métallurgie, 25 rue de Clichy, Paris, 9e.

A NEW LABORATORY IN BIRMINGHAM.—The College of Technology in Birmingham is one of the largest centres in this country for the teaching of production engineering, and an important addition to its facilities was made by the recent completion of a new metrology laboratory. This laboratory has received the approval of the National Physical Laboratory as a gauge testing centre, and is approved for the same classes of work for the Aeronautical Inspection Department (Ministry of Supply). In the laboratory accurate measurements can be made of various classes of plain and screwed plug gauges; plain and taper ring gauges; parallel and taper plain gap gauges; length, height, depth and thickness gauges; screw plug gauges; profile and angle gauges. We are informed that the Production Engineering Section of the College, in order to make the use of this laboratory realistic for students, will undertake fine measurement work for outside organisations, particularly for small engineering and other concerns which cannot afford to purchase expensive fine measurement equipment such as is now available in the College.

PRESTRESSED CONCRETE FENCING.—Prestressed concrete fencing is being used for the first time in this country on any significant scale by the Metropolitan Water Board at Chingford, Essex, for the recently completed 3600 million gallon William Girling reservoir. The design used was developed after close collaboration between the New Works Engineer of the Board and his department, and Dow-Mac (Products), Ltd., which was responsible for the manufacture of the units. The fence consists of posts at 9ft intervals with top and bottom rails spanning between them, which support seventeen pales to each bay. All the units are prestressed. The posts are 8ft 9in long, 7½in deep from back to front, 4¼in wide on the face and 4¾in at the back; each weighs 308 lb and is prestressed with six 10 S.W.G. wires. Each rail weighs 129 lb and is prestressed with eight 10 S.W.G. wires, and each pale weighs 36 lb and is prestressed by four 10 S.W.G. wires.

Personal and Business

DR. G. M. LEES, F.R.S., has been re-elected president of the Geological Society of London.

MR. LESLIE GAMAGE, of the General Electric Company, Ltd., has been elected president of the Institute of Export for the tenth consecutive year.

THE ANGLO-IRANIAN OIL COMPANY announces that Mr. C. H. E. Rebbeck has been appointed resident engineer for the construction of the refinery at Fremantle, Western Australia.

LLOYD'S REGISTER OF SHIPPING has agreed to release its chief ship surveyor, Mr. R. B. Shepheard, C.B.E., M.I.N.A., for an important appointment with the Shipbuilding Conference, which he will take up later in the year.

FLETCHER MILLER, Ltd., Hyde, Manchester, announces that its Southern Works have been transferred from Hayes to Alma Wharf, Dormay Street, Wandsworth, S.W.18 (telephone, Vandyke 6033; telegrams, "Kooledge, Put, London").

MR. GORDON E. WEST has been appointed sales manager for London and the Home Counties of Whitehouse Industries, Ltd. (Philidas Division). For the present, Mr. West will operate from Mansard Cottage, West Farm Avenue, Ashtead, Surrey.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., announces the following appointments:—Mr. E. Mead, M.I.E.E., assistant manager, London office; Mr. R. Allen, A.M.I.E.E., assistant manager, Birmingham office; Mr. T. Gill, A.M.I.E.E., manager, Swansea sub-office.

MESSRS. COODE, VAUGHAN-LEE, FRANK AND GWYTHER state that they are taking into partnership, from June 1st, Colonel Gerald H. Vaughan-Lee, R.E. (Ret.), A.M.I.C.E. The firm will continue to practise at 9, Victoria Street, London, S.W.1, but under the name of Coode and Partners.

THE MUTUAL SECURITY AGENCY MISSION TO THE UNITED KINGDOM has announced that the A.P.V. Company, Ltd., Wandsworth Park, S.W.18, is to use the processes and technical data of the Cooper Alloy Foundry Company, Hillside, New Jersey, U.S.A., for the manufacture of stainless steel valves.

HENRY ROGERS (LONDON), Ltd., is the style of a new private company formed to continue, in association with C. Tennant, Sons and Co., Ltd., the business carried on since 1807 under the title of Henry Rogers, Sons and Co. Mr. E. W. D. Tennant is the chairman, and Mr. J. C. Dekker, managing director, of the new company, the address of which is Plantation House, Rood Lane, London, E.C.3.

VICKERS-ARMSTRONGS, Ltd., states that, following the death of Commander Sir Robert Micklem, C.B.E., Sir James Reid Young has been appointed chairman. Major-General C. A. L. Dunphie, C.B., has been appointed managing director, engineering works and shipyards, and Mr. E. J. Waddington, director of administration. Major Sir Hew Kilner continues as deputy chairman and managing director, aviation.

SMALL AND PARKES, Ltd., Manchester, states that Mr. Edward J. Parsons has been appointed London manager in succession to Mr. H. M. Lawrence, who will retire on May 31st. Mr. A. K. Hebditch, service manager at the firm's Wimbledon depot, has been appointed London technical manager. These appointments coincide with the opening of the company's new office at 76, Victoria Street, London, S.W.1 (telephone, Victoria 1845), from which Mr. Parsons and Mr. Hebditch will work. The depots at Wimbledon and Leyton will continue to operate.

British Patent Specifications

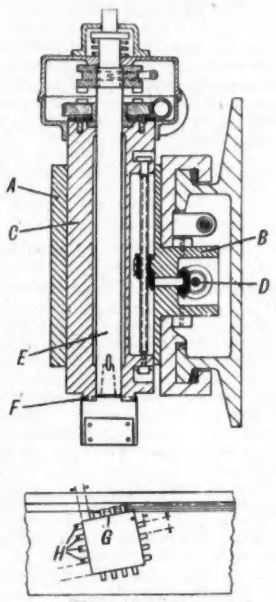
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

MACHINE TOOLS

671,364. October 28, 1948.—METAL PLANING MACHINES, Oskar Waldrich, Werthenbach, Kreis Siegen, Germany.

The drawing shows a detail of a planing machine according to the invention, in longitudinal section through its multi-sided tool-holder. The cross beam can as usual be raised and lowered on the side columns of the machine and the tool-head can be fed horizontally along the ways and clamped to the beam. A gripping holder *A* having an octagonal bore is pivotally mounted on the head by a spigot *B* so that its axis can be set and the holder fixed at any desired angle in relation to the bed, i.e., laterally in relation to the direction of movement of the workpiece. In the holder is an octagonal spindle carrier *C*, at the upper end of which is gearing used to effect the downward, rotational and upward movement of the tool holder. In the beam is a driving shaft *D*, which through gearing provides means of height adjustment of the carrier and the tool. This height adjustment can be effected either at the beginning of machining for feed in the horizontal direction or as a feed to machine vertical surfaces. The arrangement described makes it possible to avoid the use of a number of tool-heads on a planing

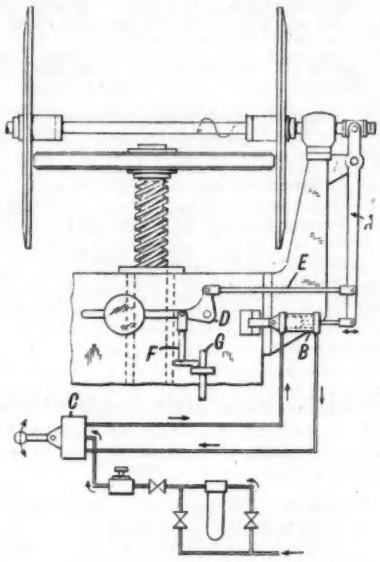


No. 671,364

machine and to carry out machining horizontally as well as vertically. The gearing arranged at the upper end of the spindle carrier is motor driven. At the lower end of the spindle *E* is the tool-holder; a coupling under the action of a helical spring ensures rigid connection of the holder with the lower end of the spindle carrier. To reciprocate the spindle it is provided with a grooved collar controlled by a pivoted fork, which is rocked at appropriate times by mechanism not shown. In the raised position of the spindle shown it is locked to the carrier by the dog coupling *F*. When the spindle is to be rotated the fork moves it downwards against the pressure of a spring, thus disengaging the coupling and engaging another dog coupling on a wormwheel, the worm of which is on the spindle of the motor. The lower drawing shows diagrammatically a part of a workpiece and above it, in outline, a tool-holder. The workpiece lies with its edges parallel to the direction of movement of the table. The square tool-holder on each side carries two sets of four roughing tools and two sets of four finishing tools. The tool-holder on its edge *G* in working position forms with the direction of movement (parallel with the workpiece edge) an acute angle of 15 deg. in counter-clockwise direction. In the position shown, in the previous stroke, the roughing tools *H* have roughed out a strip and the holder is then rotated through 120 deg. to bring the finishing tools into position. The method of setting the tools in the holder is described in the specification.—*May 7, 1952.*

671,400. May 31, 1950.—FLY PRESSES, Omes, Ltd., Beverley Works, Willow Avenue, Barnes, London, S.W.13. (*Inventor: Ralph Walter Smart.*)

One of the arms which supports a bearing for the driving shaft of a fly press carries a bracket in which is pivoted a clutch lever *A* for engaging and disengaging the clutches afforded by the flywheel and friction discs. Movement of the lever shifts the driving shaft endwise in one or other direction. Below the bracket the lever arm extends downwards and at its bottom end is connected to the rod of a control device *B*. On one of the side members of the press is a hand control valve *C*. The valve contains mechanism through which compressed air can be admitted to either of two feed pipes leading to opposite sides of the piston in the cylinder *B*. The valve *C* has the characteristic that the pressure delivered to either of the pipes is proportional to the pressure exerted on the handle. Therefore the pressure of the discs on the flywheel is proportional to the operator's pressure on the handle and determines the strength of blow of the press. There is a natural tendency of the tup to fall by gravity because its



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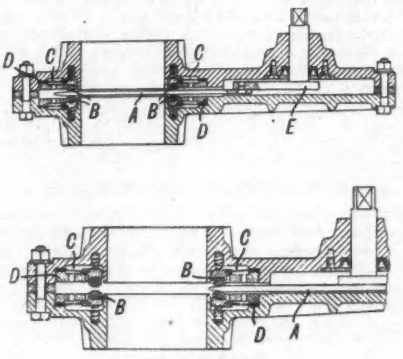
screw thread is of a steep pitch and the friction is not enough to hold the tup up. In order to counteract this tendency and to maintain the tup at its upper position, there is provided a gravity operated device for biasing the piston in *B*. The device incorporates a bell-crank lever *D* with a weight on one arm which is substantially horizontal. The shorter upright arm of the lever is coupled by a link *E* to the lower arm of the clutch lever. The weight rocks the lever in an anti-clockwise direction so as to shift the driving shaft towards the right and thereby engage the left-hand friction disc with the flywheel. The flywheel is so adjusted as to produce a slipping engagement at the clutch faces tending to rotate the screw in a direction for lifting the tup. In order to avoid over-running of the tup in the upward direction, a projection on a link *F* connected to the crank lever is engaged by a stop collar on a member *G* connected to the tup. In operation, when the tup rises to a point near the top of its stroke the stop engages the projection and any further upward movement of the tup results in a reversal of the upward drive and a downward drive by operation of the crank lever which will again be reversed as soon as the stop leaves the projection so that the light frictional pressure on the flywheel rim would maintain the stop practically in contact with the projection.—*May 7, 1952.*

VALVES

671,546. February 26, 1951.—GATE-TYPE SHUT-OFF VALVES, Teddington Controls, Ltd., Teddington Works, Windmill Road, Sunbury-on-Thames, Middlesex. (*Inventor: James Raymond Coen.*)

As shown in the drawing, the body or housing consists of two castings with a fluid passage. The castings are bolted together with a spacer ring inserted between them to form a transversely extending pocket, which accommodates the sliding gate member *A*. At each side of the gate member is a sealing ring *B* concentric with the passage and mounted in an annular carrier, which is secured to the inner edge of an annular flexible diaphragm *C*. This diaphragm is clamped at its outer edge against a shoulder on the valve body by a lock ring *D* screwed into the valve body. Each sealing ring is maintained in contact with the gate member by a series of compression springs located in pockets



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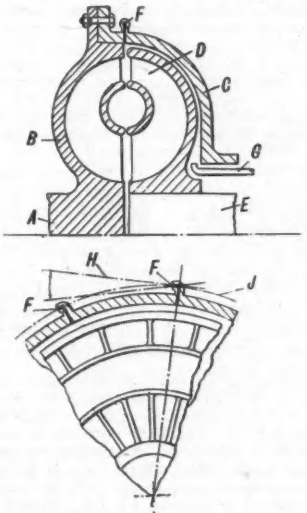
in the valve body and bearing upon the end face of the sealing ring carrier. Outward movement of the sealing ring under the action of the loading springs is limited by engagement of a shoulder on the carrier with the inner edge of the lock ring. It will be noted that the carriers and diaphragms are arranged within pockets which are in permanent communication with the fluid passage so that when the valve is closed the loading of the sealing ring on the upstream or inlet side of the gate member by the springs is augmented by the pressure in the fluid passage acting upon the diaphragm. The gate member is actuated through a crank *E* from an operating spindle mounted in an extension of the casting. The stroke or range of movement of the gate member is related to the diameter of the sealing rings so that even when the member is fully withdrawn the tip of the gate does not pass from between the opposed sealing rings, whilst the edge of the gate member is bevelled or chamfered to ensure that the gate will move smoothly between the sealing rings in the direction to close the valve. The sealing rings may be formed of any suitable material which will depend upon the type of fluid under control and the operating conditions.—*May 7, 1952.*

HYDRAULIC MACHINERY

670,848. May 8, 1950.—HYDRAULIC COUPLINGS, Henry George Yates, of The Riding, Riding Mill, Northumberland, and The Parsons and Marine Engineering Turbine Research and Development Association, of Pametrada Research Station, Wallsend, Northumberland.

This invention relates to hydraulic couplings and its object is to provide an improvement in or modification of couplings claimed in Specification



No. 670,848

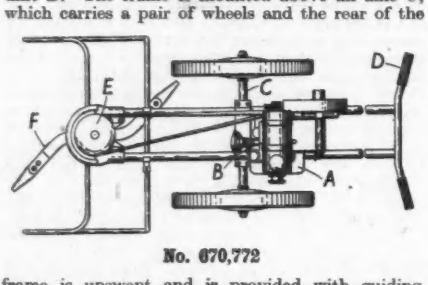
No. 623,266. A driving shaft *A* has an impeller *B* to which is attached a rotary casing member *C* of substantially toroidal cross section. The liquid from the impeller is discharged against a series of vanes *D* rigidly mounted on a driven shaft *E* co-axia with the driving shaft, the driven vanes being housed within the casing, but not connected to it. At the outer periphery of the casing a number of nozzles

F are arranged to discharge liquid backwards, in the opposite direction to the peripheral motion of the casing, these nozzles communicating with the interior of the casing which is supplied with liquid by way of a feed pipe *G*. The size of the nozzles is determined by the desired rate of discharge of the liquid and the geometrical axes of the nozzles are inclined inwards at angles of about 10 deg. to the tangents *H* to a circle *J* concentric with the axis of the coupling and passing through the centres of the discharge openings of the nozzles. With such an arrangement, notwithstanding the increase of pressure in those parts of the nozzle channels furthest from the axis, the liquid jets emerge backwards, i.e., in a direction opposite to that of the casing, and are not inclined outwards in relation to the respective tangents.—*April* 23, 1952.

AGRICULTURAL ENGINEERING

670,772. August 29, 1947.—Machines for Cutting Vegetation, John Wallace Forrester, St. Lawrence, Kilmacolm, Renfrewshire.

The object of the invention is to provide a new machine particularly suitable for cutting crops, bracken grass and rough vegetation. Referring to the drawing, the machine comprises a frame constructed of a pair of tubular members with horizontal supports upon which is mounted an adjustable platform *A* to which is bolted a petrol engine unit *B*. The frame is mounted above an axle *C*, which carries a pair of wheels and the rear of the



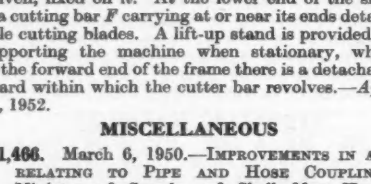
No. 670,772

frame is upswept and is provided with guiding and controlling handles *D*. The forward end of the frame has a boss through which passes a vertical spindle, the upper end of which has a pulley, *E*, belt driven, fixed on it. At the lower end of the shaft is a cutting bar *F* carrying at or near its ends detachable cutting blades. A lift-up stand is provided for supporting the machine when stationary, whilst at the forward end of the frame there is a detachable guard within which the cutter bar revolves.—*April* 23, 1952.

MISCELLANEOUS

671,466. March 6, 1950.—Improvements in and relating to Pipe and Hose Couplings, Minister of Supply, of Shell Mex House, Strand, London, W.C.2. (*Inventors: Arthur William Capps and Victor William Higgs.*)

The invention provides a quick-release pipe coupling having two concentric co-operating parts, one attached to each pipe end and a resilient gasket located between. As shown in the drawing, between the surface of the first shoulder portion *B* of the male member *A* and the surface of the undercut *C* of the female member is a flexible endless smooth surface hard rubber roller *D*, which is reinforced with a helical spring. The free diameter of the roller is slightly more than the radial distance between the surfaces which it contacts. In the closed condition



No. 671,466

of the coupling the roller abuts a transverse surface *E* of the undercut on one side and of the outward shoulder *F* on the other. The coupling is thus locked in the closed condition in so far as relative axial motion of the members for unlocking is resisted by the roller, which, must be deformed to pass between the projections. Fluid tightness of the coupling is ensured by the contact of the roller with the male and female members. Unlocking the coupling is effected by an axial pull which, when it reaches a predetermined value, overcomes the resistance to deformation of the roller and the two members may be pulled apart. In the process the roller is rolled along the undercut to the position shown in dotted lines. Locking the coupling is performed by a reverse operation in which the male member rolls the roller over the projections until the members are in the locked position.—*May* 7, 1952.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME and PLACE at which the meeting is to be held should be clearly stated.

Incorporated Plant Engineers

Mon., May 26th.—West and East Yorks Branch: The University, Leeds, "Plant Re-organisation," A. G. Dewhirst, 7.30 p.m.

Thurs., May 29th.—South Yorkshire Branch: Grand Hotel, Sheffield, "Foundry Mechanisation," P. McA. Martin, 7.30 p.m.

Fri., May 30th.—Birmingham Branch: Imperial Hotel, Temple Street, Birmingham, "Refrigeration," A. C. Curgenven, 7.30 p.m.

Institute of Industrial Administration

Wed., May 28th.—Fyvie Hall, The Polytechnic, Regent Street, London, W.1, "The Human Factor: The Vitality of Management," "Selection and Training," A. Roy, 6.30 p.m.

Institution of Electrical Engineers

To-day, May 23rd.—Utilisation Section: Savoy Place, London, W.C.2, "The Use of Electricity in a Modern Iron and Steel Works," W. F. Cartwright, 5.30 p.m.

Tues., May 27th.—Scottish Centre: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, Annual General Meeting, 7 p.m.

Wed., May 28th.—Radio Section: Savoy Place, London, W.C.2, "Recent Progress in Colour Television Technique in the U.S.A.," A. G. Jensen, 5.30 p.m.

Institution of Mechanical Engineers

Sat., May 24th.—Southern Branch, Graduates' Section: Visit to Poole Power Station, 2.30 p.m.

Royal Institution of Great Britain

To-day, May 23rd.—21, Albemarle Street, London, W.1, "Continuous Creation," Sir Harold Spencer Jones, 9 p.m.

Society of Instrument Technology

Tues., May 27th.—Royal Society of Tropical Medicine and Hygiene, Manson House, Portland Place, London, W.1, Annual General Meeting, "Recent Advances in the Industrial Use of the Microscope," E. W. Taylor, 6.30 p.m.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 24, Victoria Street, London, S.W.1.

METHODS FOR THE SAMPLING OF FERROUS METALS AND METALLURGICAL MATERIALS FOR ANALYSIS: PART 1, IRON AND STEEL.

No. 1837 : 1952. This specification is intended for use in conjunction with B.S. 1121, "Methods for the Analysis of Iron and Steel" and those specifications which include clauses governing chemical composition and sampling. It is divided into four main sections:—Section 1 sets out the general requirements; Section 2 deals with liquid iron and liquid steel; Section 3 covers the sampling of pig, cast and wrought iron; and Section 4 includes the sampling of steel in the form of ingots, castings, blooms, billets, slabs, heavy sections, plates, light sections, bars, rods, wire, sheet, strip and tubes.

The methods described are those which have been found most satisfactory in practice. As is the purpose of the methods of analysis specified in the various parts of B.S. 1121, the standard is primarily intended for referee purposes and should be considered as a guide to sound sampling procedure rather than as a rigid specification. Price 2s. 6d.

SHEAR BOLTS AND NUTS FOR AIRCRAFT

No. A.57/58 : 1952. These specifications relate to the material, dimensions, finish and identification of close tolerance, hexagonal headed shear bolts and slotted and thin hexagonal nuts in high-tensile steel for use on aircraft. They are published together as one document: A.57 deals with the shear bolts and A.58 relates to the nuts, the shank chains covered ranging in $\frac{1}{16}$in from $\frac{1}{4}$in to $\frac{1}{2}$in diameter. Price 3s.

GENERAL REQUIREMENTS FOR THE METAL-ARC WELDING OF MILD STEEL

No. 1856 : 1952. This standard specifies the general requirements for the metal-arc welding of mild steel under normal conditions of manufacture and service. It deals with materials, details of butt and fillet welds, information required by the welding organisation, welding equipment and electrodes, welding procedure, workmanship, welding operators supervision and inspection and heat treatment in testing. One appendix gives useful information on butt welds, including a full range of recommended preparations, and another gives information on fillet welds.

The requirements are not all applicable to certain forms of construction nor does the standard specify allowable stresses in welds or methods for their testing. Reference should, therefore, be made to the standard for a specific application where such a standard exists. If no such standard is available for the type of construction required by the purchaser, B.S. 1856 can itself be used provided that such additional requirements as are necessary in the specific case, e.g., permissible stresses in welds and the tests to be applied, are agreed between the purchaser and the contractor.

The standard will be of value not only as a basis of contract but also as a useful reference for all concerned with metal-arc welding. Price 5s.

CHART RANGES FOR TEMPERATURE RECORDING INSTRUMENTS

No. 1794 : 1952. This standard makes recommendations for the temperature ranges of charts used in recording instruments actuated by gas expansion, mercury-in-steel, platinum/rhodium thermocouple, resistance thermometer, radiation pyrometer. As the preferred ranges have been compiled from data supplied by many instrument manufacturers their calculation has been achieved by grouping and consolidating the ranges favoured by individual users. Where minor differences in starting point and range were encountered during compilation they were embodied, wherever possible, in one range containing their maximum and minimum temperatures. There are in use many preferred ranges which are peculiar to a particular industry or process and these have been included in the ranges specified in this standard. In most cases these special ranges have developed from the need to provide openness of scale at important temperatures, and their use requires some special arrangement of the measuring system in order to provide the necessary sensitivity. Although these chart ranges embrace the whole of the useful temperature scale it is appreciated that not every instrument manufacturer will be in a position to adopt them in their entirety, especially since some of them are for use in conjunction with particular types of measuring system. Further, the use of the whole of such a comprehensive selection of ranges is unnecessary when instruments are manufactured for a particular section of industry. Price 2s.

COMPRESSED ASBESTOS JOINTING FOR THE PETROLEUM INDUSTRY

No. 1832 : 1952. This standard covers two grades of compressed asbestos jointing from $\frac{1}{64}$in to $\frac{1}{8}$in in thickness. The two grades are Grade G for general low-duty purposes, such as marketing and transportation, and Grade H for higher duty purposes, such as those involving contact with oil and mainly used in refinery applications. The standard also gives full details of the physical characteristics of the jointing, together with limits for tensile strength and resistance to oil and water, ageing, cohesion and compression. Furthermore, a service test is provided for, and clauses cover sampling, marking and inspection. The appendices to the document give details of the tests as well as itemised drawings covering the apparatus to be used for the service test. Price 2s. 6d.

MILK STRAINERS

No. 1838 : 1952. This standard has been prepared primarily in order to obtain interchangeability between filter plates and filter media and to ensure a good quality of workmanship. No attempt has been made to standardise the shape of the strainer body except in so far as is necessary to ensure that the filter plate makes a good fit. Tests have shown that flat filter plates perforated as specified in the standard give the fastest rate of flow with the least displacement of filter media by the milk. The standard specifies the material from which the strainer bodies and perforated plates should be made and lays down a performance standard for the filter medium. Additionally, a marking clause is provided which stipulates the marking both of the strainer and the filter media. Price 2s.

LENGTH BARS AND ACCESSORIES

No. 1790 : 1952. This is the latest addition to the series of British Standards for engineers' precision tools. It relates to cylindrical bar length gauges in both inch and metric units, and standards of accuracy are specified for reference, inspection and workshop grades. In addition, the essential features of design and accuracy are specified for the two types of accessories commonly used with workshop bars, namely, those for use with collet attachments and those for use with screws and studs. Recommended sets of workshop bars are given in an appendix. Price 3s.